ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. LI. No. 11. New York, March 17, 1904.

TABLE OF CONTENTS

	Page
LEADING ARTICLES:	
Atlantic Type of Passenger Locomotives for the Wabash Ry. (illustrated)	249
Repairs of the Water-Works Pumping Station at Evansville, Ind.	250
Further Notes on the Collapse of the Darlington Building (illustrated)	250
Experience in Thawing Water Pipes by Electricity	251
Electric Traction for Freight Transportation in the Chicago Telephone Tunnels (illustrated)	251
The Use of Pulverized Coal for Fuel Under Steam Boilers (illustrated). J. M. Sweeney, M. W. S. E.	252
Specifications for Pig Iron and Iron Castings. Robert Job, M. Am. Inst. Min. E.	253
The Design of Reinforced Concrete Beams (illustrated)	254
Concerning the Projected Northern Canadian Transcontinental Railway	254
Sea Strength of the Chief Naval Powers (illustrated)	255
A Memorial Statue to James Watt	255
Some Examples of Exterior Wall Damage in the Baltimore Fire (illustrated)	261
Committee Reports at the Annual Meeting of the American Railway Engineering and Maintenance of Way Association (illustrated)	261
A New Derail for Side Tracks (illustrated)	265
The Construction and Operation of Coal Piers (illustrated)	265
The Location of the First Division of the Hankow-Canton Ry. Jesse W. Miller	268
A Concrete-Steel Pier and Girder Footing for Retaining Walls (illustrated)	269
An Irrigated Sugar Plantation in the Sandwich Islands. C. H. Kluegel, M. Am. Soc. C. E.	269
A Bituminous Coal Breaker (illustrated). Lewis Stockett, M. Am. Inst. Min. E.	270
The Electric Steel Furnace at Gysinge, Sweden (illustrated). F. A. Kjellin	272
ENGINEERING NEWS OF THE WEEK	255
EDITORIAL COMMENT.—Where Should the Responsibility be Placed for Safe Construction?——The Coming Work of River Regulation——Railway Promotion and Construction in China——Leaving Faucets Running to Prevent Freezing of Water Mains	256
EDITORIAL.—The Protection of Fireproof Buildings Against Exposure Fires	257
LETTERS TO THE EDITOR.—Reasons Favoring the Use of Studs in Marking Sewer Branches: Ernest McCullough——The Advantage of a Short Tripod (illustrated): W. H. Hendricks——Methods of Obtaining Mean Velocity of a Cross-Section in Gaging Streams: H. F. Robinson——The Permanent Expansion of Cast-Iron by Heat a Danger in Building Construction: Alex. E. Outerbridge, Jr.——A Hot-Water Thaw-Box for Dynamite (illustrated): Joseph H. Harper——Why Does Earth Shrink? Wm. D. Faucette.——The Permissible Working Unit Shear for Concrete-Steel Beams: L. J. Johnson, Assoc. M. Am. Soc. C. E.——The Government Cement-Making Plant at the Tonto Dam, Arizona: Wm. G. Hartranft, Assoc. Am. Soc. C. E.	258-260

ATLANTIC TYPE PASSENGER LOCOMOTIVES FOR THE WABASH RAILWAY.

To provide for the extra traffic in connection with the St. Louis Exhibition, and particularly for the traffic of the Chicago and St. Louis division, the Wabash Ry. has had several large passenger engines of the Atlantic (or 4-4-2) type built by the American Locomotive Co., the engines being built at the Brooks Works, Dunkirk, N. Y. For information respecting these engines we are indebted to the builders and to Mr. J. B. Barnes, Superintendent of Motive Power and Machinery of the Wabash Ry. A general view of one of the engines is shown herewith.

There are now twelve of these engines in service, and they handle trains of four to eight cars on a schedule speed of 55 miles an hour. The average train load is about 275 tons.

The main frames are of the ordinary type, and have heavy bars under the driver boxes to hold the feet of the pedestals rigidly together. Behind the rear drivers, however, steel plate or slab frames are bolted to extensions of the main frames, and these carry the pedestals for the trailing wheels. The boiler is of the extended wagon-top type, with a top seam in the conical portion next to the smokebox, and a side seam in the circular portion next to the firebox. The firebox is of the radial-stay type, extended over the frames, and with its back head sloped 1 in 4. It has alternate rigid and flexible stay-bolts, staggered in the alternate rows, as shown. They are all 1-in. diameter, and the rigid stays have a 3-16-in. hole drilled 1¼ ins. deep at the end. The boiler and firebox construction are shown in Figs. 2 and 3. The flexible staybolts, above mentioned, are of the Acme pattern, shown in Fig. 4.

Piston valves are used, operated from eccentrics on the rear (main) driving axle. The links are behind the first driving axle; with a radius of 5 ft. 3 ins., and from the link block a bent valve rod passes up over this axle to a rocker arm on a shaft just in front of the guide yoke. To another rocker on the shaft is attached a short rod, only 12½ ins. long, which connects the rocker to the end of the valve stem. All the rods are of I-section. The safety valves are mounted in a special fitting behind the dome, and the steam turbine and dynamo for the Pyle electric headlight are close in front of the cab. There is a 9½-in. Westinghouse air-pump for the brake system, and the brake reservoirs, 16 ins. diameter and 10 ft. long, are placed under the running boards. The brakes are applied to the driving, truck, trailing and tender wheels.

The following is a list of the principal dimensions of these engines, given in our standard form:

Dimensions of Atlantic Passenger Locomotive; Wabash Ry.

RUNNING GEAR:	
Driving wheels (4), diameter	6 ft. 11 ins.
Truck wheels (4), diameter	3 " 0 "
Trailing wheels (2), diameter	4 " 3 "
Tender wheels (8), diameter	3 " 0 "
Driving wheel centers, cast steel, diameter	6 " 4 "
Driving-wheel tires secured?	By shrinkage and retaining rings.
Engine truck,	Swing center.
Journals, driving axles	9½ × 12 ins.
WHEELBASE: Driving	7 ft. 6 ins.
Truck	6 " 0 "
Total engine	30 " 11½"
Tender	17 " 0 "
Engine and tender	56 " 0 "
Engine truck-pin to c. leading dr'v'g wh'l.	8 " 1 "
Wheels having blind tires	None
WEIGHT IN WORKING ORDER:	
On driving wheels	96,700 lbs.
Engine, total	180,700 "
Tender empty	55,460 "
Engine and tender in working order	310,700 "
CYLINDERS: Two	21 × 26 ins.
Crossheads and guides	Alligator; two-bar
Connecting rod, length between centers	11 ft. 3½ ins.
Side rods	Solid ends
VALVE GEAR: Type	Link
Ports: Steam	1¾ × 25½ ins; Exhaust 63 sq. ins.
Bridges, width	3½ ins.
Valve, Piston, diameter	11. ins.
Valves, Maximum travel	5 9-16 in.
" inside lap	0; outside lap 1¼ "
" lead (full gear)	1-16-in.
BOILER: Type	Extended wagon-top
Barrel, diam. outside first ring	5 ft. 4¾ ins.
Barrel plates	½ to ⅝-in.; smokebox tube-plate ½-in.
Horizontal seams	Sextuple riveted
Circumferential seams	Triple riveted
Height from rail to center line	9 ft. 4 ins.
Injectors (2)	No. 10 Ohio
Working steam pressure	200 lbs.
FIREBOX: Type	Radial stay
Length inside	8 ft. 6 ins.; width inside 5 ft. 3 ins.
Depth at front	6 " 3½" depth at back 5 " 3½"
Thickness, side, back and crown plates	⅝-in.
Thickness tube plate	½-in.
Crown stays	Radial, 1-in.
Grate bars	Rocking
Stay bolts (drilled)	1-in.; alternating with flexible staybolts
Water spaces, width, front, 5 ins.; back and sides,	4½ ins.
TUBES: Iron	Number 294
Pitch	2⅜ ins.
Diameter, outside	2 ins.; holes drilled 2 1-16-ins.
Length over tube plates	16 ft. 4 ins.

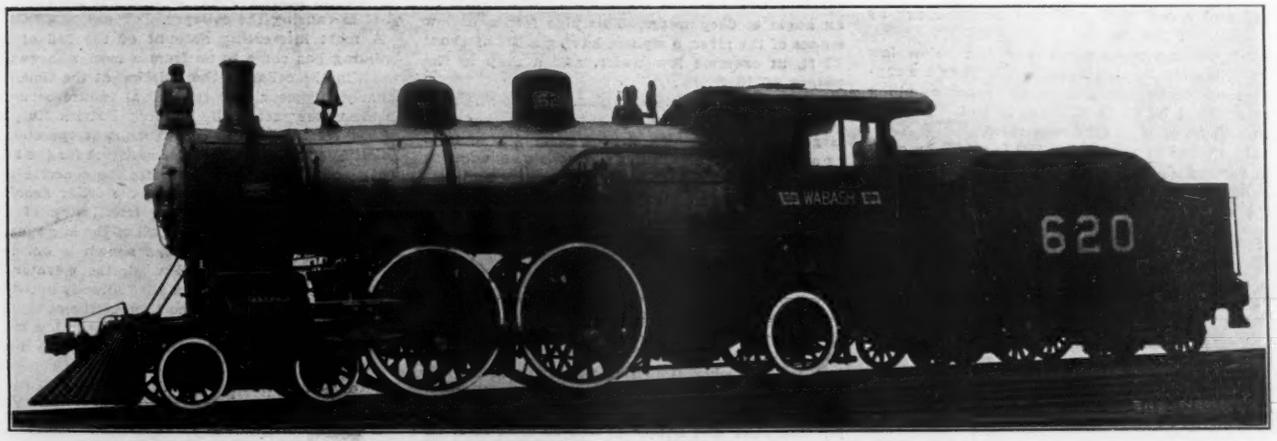


FIG. 1. ATLANTIC TYPE OF PASSENGER ENGINE FOR THE WABASH RY.
J. B. Barnes, Superintendent of Motive Power and Machinery. American Locomotive Co. (Brooks Works, Dunkirk, N. Y.), Builders.

HEATING SURFACE AND GRATE AREA:		
Heating surface, tubes (interior area)...	2,490.0	sq. ft.
" " " firebox	177.0	"
" " " total	2,676.0	"
Grate area	43.7	"
MISCELLANEOUS:		
Exhaust nozzle (single) diameter.....	5½	ins.
Exhaust nozzle, distance below center line boiler	3	"
Smokestack, diam. at top..16¾ ins.; at base ..14½		"
" height above smokebox.....3 ft. 1½		"
" height of top above rail.....15 " 3		"
Capacity of tender tank.....	6,000	gallons
Capacity of coal space.....	12	tons

REPAIRS OF THE WATER-WORKS PUMPING STATION AT EVANSVILLE, IND.

The Ohio River at Evansville has a range of about 50 ft. between high and low water. The water-works pumping station is located at a point subject to overflow at high water and is built on an artificial mound about 50 ft. high, close to the water edge. The pumps are founded on a caisson. About two months ago it was noticed that the ground on the river side of the station was settling, and that black mud was discharged from the water pipes. The presumption was that the cast iron suction pipes had been ruptured and a cavity was formed at the break by the action of the pumps.

These suction pipes are a few feet below low water and pass through a sandy soil. They are supported on straps attached to a cap across piling driven about 30 ft. in this sandy soil. There is about 45 ft. of clay fill above them.

This method of supporting 300 ft. of 30-in. cast-iron flanged pipe, proved to be very poor, and as a result, the pipes were pushed downward, and perhaps sidewise, by the fill. The defect was not noticed until the pumps had sucked out enough of the fill to cause a cave from the surface. At the time it was though that a line of steel piling of the interlocking channel bar construction driven across the front of the building, which rests on a concrete footing about 6 or 7 ft. below the surface, would stop the caving toward the building, and this piling was ordered, but there was much delay in its delivery, and the final destruction of the pumping station wall took place before it arrived. The west wall, which was 95 ft. long, 40 ft. high and 30 ins. thick, had to be pushed out to keep it from falling on the machinery. The roof was shored up, and the wall removed successfully.

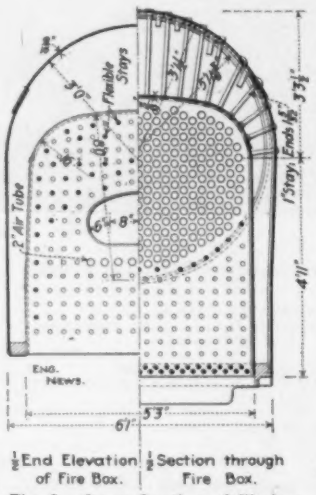


Fig. 3. Cross-Section of Firebox.

In the meantime, pump boats were set to work forcing water into the old reservoirs, and some temporary pumps were installed to keep the city supplied with water while the new intake pipe was being laid. While the pressure from these makeshift plants was not always what was desired, the city has not been entirely out of water, and probably will not be before the new intake pipe is finished.

On account of the stage of the river, pipes could not be put in where the old ones were, so new connections were made in the well to both pumps, and a single 30-in. cast-iron ball-and-socket pipe was run from the hole cut in the side of the dry well 18 ft. above the pump suction and out through a tunnel to the toe of the slope of the mound and from this point through a trench about 13 ft. deep, to the river, where the ordinary strainer end was put on, pitching downward on an angle to deep water. This pipe forms, at low stages of the river, a siphon, having a lift of about 12 ft. at extreme low water, and a drop to the pumps of 18 ft.

A 30-in. check valve was placed in the line next to the suction end, and a 20-in. connection to a large flush tank, which, in this case, is to be used as a priming tank. The necessary air connections were made at the high point in the "U" and also on the lower side of the check valve for removing air when starting and to take out the accumulation of air when in operation. The necessary valves were placed in the 20-in. priming line, also in the connection to each pump. The estimated cost was $10,000 and the work was done for about that sum.

The 30-in. suction is about 350 ft. long. There were about 1,000 yds. of excavation; all trenches and tunnel being timbered on all sides. The trenches are 40 ft. deep where they pass through the mound. The steel piling which was ordered for this work and not used, will be used later on for the permanent repair work. The plans for the permanent work are not yet drawn up, but the pipes will be laid through a tunnel in about the same position they now are.

The above described work of repair has been carried out under the direction of Mr. W. S. Ludington, of the firm of Ledlie & Ludington, Consulting Engineers of St. Louis, and with the co-operation of Mr. Charles Thuman, Superintendent of Water-Works. We are indebted to Mr. Ludington for the information above given.

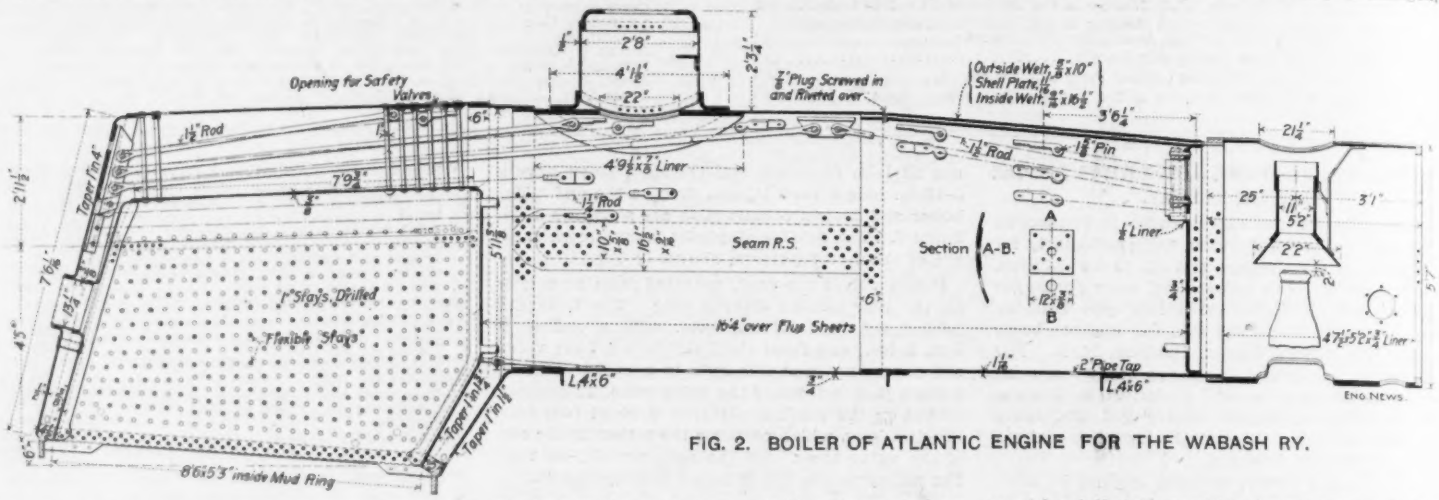


FIG. 2. BOILER OF ATLANTIC ENGINE FOR THE WABASH RY.

FURTHER NOTES ON THE COLLAPSE OF THE DARLINGTON BUILDING.

Since the report in our last issue on the collapse of the Darlington building in New York City was written, the official investigation of the accident has been begun by the selection of a Coroner's jury. As yet little has developed to throw any light on the case. The jury, it may be noted, is composed almost wholly of architects, builders and contractors experienced in building work.

A verbal preliminary report has been made to the District Attorney by Mr. H. De B. Parsons, who had been retained as expert in the criminal investigation. The essence of the report is that poor workmanship in the framework, and faulty methods of assembling and erecting, are responsible for the fall. Looseness in the column connections, and in the fastening of beams to girders and girders to columns, is given as the probable cause of the accident. A specific point referred to is the fact that the holes in the end flanges of the columns, by which the successive sections were held together, were cored instead of drilled as the law requires. It is rumored that the framework had been found, a week or two before the collapse, to be out of plumb, and that it was pulled back to position by tackle. This would have strained the frame, especially the column connections, in a dangerous manner.

The condition of the foundations of the building is not yet definitely known, but it is probable that they will be found substantially unchanged, or at least that they will be found to have had no part in causing the collapse.

A most interesting account of the fall of the building has come to us from a man who was at work in the cellar of the building at the time. It clearly suggests that the initial failure occurred in the upper part of the building. Patrick Murphy, of 364 West 117th St., New York, was operating a hoisting engine used to raise concrete for the floor work from the basement, where the concrete was mixed. This engine stood on the cellar floor, at the northeast corner of the front wing of the building, close to the south wall of the large (east) light-court (see the floor-plan shown in our last issue). The engine faced west, the elevator to which it belonged being installed directly opposite, near the west wall. At the time of the collapse a gang of men was at work in the cellar, a few steps from the engine, mixing concrete for the ninth floor, where about half the floor-concrete had been placed. These men were all killed, but Murphy escaped without a scratch. Of those in the building at the time, all but three were either killed or

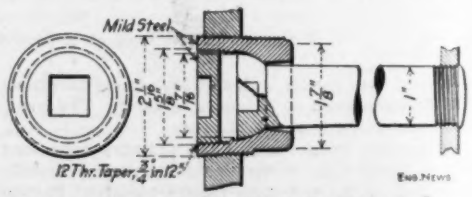


Fig. 4. Acme Flexible Staybolt; Wabash Ry.

seriously injured, and of the three, Murphy went through the least severe ordeal, so that his account of what occurred when the structure collapsed will be as reliable as any. He says:

I was operating the hoisting engine for the elevator carrying concrete from the basement for the construction of the floors. The engine stood on the basement floor in the front wing of the building, near the east wall and close to the large light-court. On Feb. 27, four days before the accident, this engine was moved down from the first floor to the basement. There were two hoisting engines on the first floor, one used for hoisting iron and the other for

hoisting brick, but neither of these was running on the day of the collapse. My elevator was opposite the engine, alongside the west wall, and the hoisting rope led straight over from the engine.

At about 1.30 p. m. of March 2 I was hoisting a load of concrete to the ninth floor, where the floorwork was being put in. After stopping the elevator at the ninth floor for the barrows to be taken off, I started around from the right-hand side of the engine to the furnace door. Just then I heard a terrible noise, what seemed to be an iron beam come crashing down from about the fifth or sixth floor, going down through each floor and striking near the engine. It seemed to have come from directly over my head. "My God!" I said to myself, "there must be something greatly wrong up there." In a second or so there was a great crushing, tearing racket, and then I realized that everything was coming down on top of us.

It was all over in, I judge, about half a minute. I was standing between the boiler and the east wall in total darkness, unhurt; iron beams were piled ten feet deep over my head, and my feet were buried in concrete to my knees, while steam and smoke from my engine surrounded me. After freeing myself I made my way forward along the wall through an open space in the wreckage to the front wall, going through a door opening in this wall to the space under the sidewalk and from there out to the open air. Up to then I had no idea that the whole building had fallen, and was never more surprised than when I turned around and found the whole building fallen in ruins.

(In answer to a question:) The noise overhead was the first thing unusual I noticed. From my engine I could see through almost the whole cellar, and I noticed no noise or movement anywhere down there.

It would appear from this account that there was no especial vibration or lateral pull on the building at the time of the collapse, the derrick, as also the brick-elevator, being out of commission on that day. What part was played by the iron-work stored on the tenth floor, the tier last erected, remains to be learned.

We reproduce herewith a photograph of the hoisting engine in question, after the wreckage over it had been removed. The view shows in the background a part of the light-court framing, which was left standing up to the second-floor level. The engine shown is the one which, immediately after the collapse, the owner of the building charged with the accident, claiming that its boiler had exploded and blown out the adjacent columns, a theory of the cause of the disaster which was disproved within a few hours.

HOISTING ENGINE FOR CONCRETE ELEVATOR IN DARLINGTON BUILDING.

(Immediately after the collapse of the building the owner of the building claimed that the boiler of this engine had exploded and blown away the adjacent columns. The fall completely covered the engine and boiler with wreckage. The above view, taken after the surrounding wreckage was removed, shows clearly that no explosion took place.)

EXPERIENCE IN THAWING WATER PIPES BY ELECTRICITY.

The extremely cold weather of the past winter has caused the frost to penetrate to much greater depths than ordinarily occurs and the result has been an epidemic of frozen water mains and service pipes. To cope with this difficulty the system of thawing the pipes with the aid of an electric current which was developed at the University of Wisconsin in 1899* has been extensively adopted and with most gratifying results, according to the reports that reach us. The principle of the electric thawing process is very simple. A current is taken from the electric lighting circuit at any convenient point and is reduced by a portable transformer to a low voltage. Connections are then made to the frozen pipe in such a manner that the current is passed through it and the resistance heats the pipe sufficiently to thaw the ice.

At Newark, N. J., the principal work has been the thawing of frozen lead service pipes, the only mains which froze being a few dead ends in which there was no circulation. The following notes of the method used are taken from the Newark "Call" of Feb. 28:

The city put on its fourth water wagon yesterday for the purpose of melting the water in the service pipes. All of the wagons are busy for nine hours a day. Each can thaw out from 20 to 30 house pipes a day, and one of the crews is charged with the duty of seeing that fire plugs are in order. Each wagon has a crew of five men; an electrician, driver, lineman and two helpers. The city is divided into districts and the complaints, which are coming in hourly, are taken up as quickly as possible, but when a crew gets to work on a block with notices of a dozen frozen pipes, a dozen other housekeepers who have not complained to the office will appeal to the foreman of the gang to have their supply pipes thawed, and, being on the spot, he always complies with the request.

The current used for thawing the pipes is that of the Public Corporation's electric lighting service, taken from the cables at a voltage of something like 2,500, and carried to a transformer on the wagon, which reduces the current pressure materially. It is still further reduced by water resistance between two plates in a barrel on the wagon and goes to the house wires at a pressure of from 110 to 120 volts with a high amperage of current. The leads from the barrel are heavy insulated wire, and are trailed with safety along the streets. There is wire enough to extend along the house fronts upon any ordinary block. The current is applied to the pipes by attaching one of the wires to a faucet in one house and the other to another faucet in the nearest adjoining house. The current is so regulated through the result of exhaustive experiments made by George Sanzenbacher, of the Board of Works, and Fred O. Runyon, that it cannot injure the pipes by too intensely heating them. The result is largely dependent upon the resistance of the lead pipes through their indifferent conductivity. This is so marked that on Friday an attempt to thaw a pipe failed because of a small copper wire which was attached to the pipe for the purpose of making a ground for some disused telephone. When this wire was removed the water in the pipe was quickly thawed. Before it was removed the wire was carrying the cufrent into the ground.

Up to yesterday morning there were over 800 applications for thawing filed with the Street and Water Board in Halsey St., and this probably represented about two-thirds of the homes which were shut out from the flow after the really cold weather had abated and when the householders felt that there was no danger of the pipes freezing up.

At Far Rockaway and Woodmere, L. I., the Queens Co. Water Co. has thawed frozen mains with electric current taken from the wires at 2,400 volts and reduced by a transformer to 110 volts.

In Canadian towns and cities electric thawing has been extensively used this winter. At Quebec early in January the frost had penetrated 7 ft. into the ground, which is the depth at which the service pipes were ordinarily laid, and for the first time in the history of the water-works, circulars were issued to water takers warning them to keep faucets running to prevent the freezing of the underground pipes. In addition, a house to house canvass was made by the Water Department inspectors to make sure that some faucet on each service was left partly open at night. Notwithstanding these precautions a number of small branch mains as well as many service pipes became frozen and an arrangement was made with the Jacques Cartier Electric Power Co. for the use of electric current to thaw the pipes.

At Ottawa, also, a large amount of water piping has been thawed by the aid of electricity. The "Canadian Engineer" published the following notes regarding the methods used by Mr. A. A. Dion, General Superintendent of the Ottawa Electric Co.:

This year the cold has been so severe that the city has not been able to cope with the trouble of frozen pipes with the ordinary means at hand, such as steam boilers mounted on sleighs, etc. If the freezing has extended into the street they can do little and that only at a great expense. The City Engineer having asked for our assistance, we rigged one of the company's express sleighs for the purpose. Four transformers of 5,000 watts each were put in this sleigh and connected two in series on their primary side. The secondary connections were such that when the transformers were attached to the line wires by means of small flexible rubber covered cable, each transformer got half the primary voltage for which it was made, and the secondary voltage was about 25 volts. The normal current capacity of the secondaries as connected was 400 amperes. We also had a rheostat in series with the primary cables and an ammeter. A board about 6 ft. long was set upright in the sleigh, on this a shelf was attached for the ammeter and a cross piece at the top carried two primary cutouts, to which were attached the cables to line wires. Two coils of No. 0000 insulated cable, each about 200 ft. long, were carried for secondary connections. One connection from the secondary of the transformers was made to the lead pipe inside the building where water was stopped. This connection was made by means of a brass clamp which surrounded the lead pipe without injuring it, and afforded sufficient surface to pass a large current to the lead pipe without burning it. The other secondary lead was taken to the next house or to the nearest hydrant. Care was taken to connect to the lead pipe below the point where the pipe was empty, because the empty pipe would heat too much with some currents which were used. The currents varied from about 90 amperes to about 275, and the time occupied before water would flow varied from four minutes to three hours. Usually if there is any chance of success, results will be seen in a very few minutes. In some cases we could not get enough current through to produce any satisfactory results. This was attributed to bad joints in the pipes causing unusual resistance. Three men went with the outfit, one driver and two linemen.

Mr. Harry A. Lord, Superintendent of Water-Works, at Ogdensburg, N. Y., where 4,000 ft. of water and gas pipes were reported to be frozen between the 15th and 20th of February, writes as follows:

We have continued our experiments in Ogdensburg and have been working upon one of our streets, where a stretch of about 1,800 ft. of 6-in. cast-iron main was frozen solid. The first section we undertook to open up was 700 ft. in length, and in about three hours after the current had been turned on we had water through it, leaving the hydrant open to maintain circulation. The next section was about 500 ft. to a point where the main had been cut open in an attempt to thaw it with steam. Through this opening we were enabled to extract the core of ice which came along with the current, and thus obviated the necessity of keeping the electrical current on long enough to warm the water and thaw out the ice. We are now working on the last section, and expect to have the street open in a few hours. I beg to report that the experiments have proven highly successful.

ELECTRIC TRACTION FOR FREIGHT TRANSPORTATION IN THE CHICAGO TELEPHONE TUNNELS.

The network of tunnels which has been built under the streets of Chicago by the Illinois Tunnel Co. (formerly the Illinois Telegraph & Telephone Co.) for the purpose of carrying the wires and cables of the company's automatic telephone system has been described and illustrated in our issues of May 2, 1901; July 17 and September 25, 1902, and Feb. 19, 1903. An interesting development, however, is the utilization of these tunnels

*Engineering News, Vol. Jan.-June, 1899, pp. 190, 336.

for a system of electric traction for the handling of mail, express and freight. The franchise does not permit of passenger traffic. The idea is to carry freight and coal between warehouses, wholesale houses and railway freight stations; to carry mail and express matter between the railway stations, post offices and express offices; and to carry newspapers between the newspaper offices and the railway stations. Sidings and spur tracks will be built as required. A franchise covering this privilege was granted to the company in July, 1903.

An experimental section of line has been laid and locomotives and cars put in service. A number of designs for cars have been submitted, and it is expected that contracts for 150 locomotives and 2,000 cars will be placed in the course of a few weeks. It is also stated by the company that regular traffic service will be started in September, and that about 200 locomotives and 3,000 cars will be in operation by 1905. At the present time there are 99,000 ft. of tunnels 6 × 7½ ft., and 140 four-way intersections, while about a mile of the first large tunnel 12⅔ × 14 ft. has been completed The steepest grade in the tunnels is 1.75%, and the grades at railway terminals are not to exceed 12%. These latter steep grades will form the approaches to the tunnels, which are built with the rails some 30 ft. below the street level. The four-way intersections have curves of 20 ft. radius, and the sharpest curves on the main line are 16 ft. radius. Fig. 1 shows a locomotive and train of cars in the tunnel, and also shows the track construction. Fig. 2 shows the train at one of the four-way intersections.

The track is of 2-ft. gage, laid with 56-lb. T-rails fastened by bolted clamps to cast-iron chairs embedded in the concrete floor of the tunnel, as shown in Fig. 3. The Morgan third-rail traction system is used, consisting of a perforated metal plate (½-in. thick and 4 ins. wide) forming a rack, which is bolted between two lines of timber stringers, as shown. These serve to protect and support the rail. A special construction for the tunnel work is the use of chairs of bent steel channels to support the rack. This is necessi-

Fig. 1. Electric Train in the Chicago Telephone Tunnel.

tated by the absence of wooden ties. The locomotive is of the class used in mine haulage work, but is peculiar in the method of taking current, which is explained by Fig. 4, which represents the track construction for mines. The rack rail, A, serves both for traction and as a third-rail conductor, the current being taken up by the teeth of the driving gears, B, and led to motors geared to the axles, with suitable controlling devices. The wheel, D, is one of the adhesion wheels, on the track rail, E. The track rails are used for the return current. The wheelbase of the 3-ton engine now in use is 24½ ins. The locomotive weighs about 3 tons with one motor, or 5 tons with two motors. Of the first 150 locomotives, 75 will have two 80-HP. motors and 75 will have one 75-HP. motor. The drawbar pull is about 6,000 lbs. In some cases the third-rail may be placed at the side of the tunnel wall.

The Morgan third-rail haulage system is controlled by the Morgan Electric Machine Co., of East Chicago, Ind., for which the Goodman Mfg. Co., of Chicago, Ill., acts as selling agent. This system is in extensive service for coal mine haulage. Among the advantages claimed for this system are the following: 1, No trolley pole or trolley wire is required; 2, great tractive power is obtained owing to the use of the rack rail, thus avoiding all slipping, and no sand is required; 3, the conductor is near the floor, and is covered, so as to be protected from contact with workmen or spectators; 4, facility for starting and stopping promptly without slipping the wheels; 5, ability to haul heavy loads around the sharp curves in the tunnel, 20 ft. radius; 6, a smaller locomotive can be used in place of a larger one which would be necessary to exert the same tractive power with any other system.

The actual construction of the cars has not yet been decided upon; but they will be of steel construction, mounted on trucks. They will be of different styles for different classes of freight. Some of the high side gondolas now in use have capacities of 15 and 25 tons and the latter weigh about 15 tons empty. They are 12 ft. long, 4 ft. wide, and 5 ft. high above the rail.

The President of the Illinois Tunnel Co. is Mr. Albert G. Wheeler, and the General Manager and Engineer is Mr. George W. Jackson, M. W. Soc. E., to whom we are indebted for information concerning this interesting transportation system.

FIG. 2. ELECTRIC TRAIN AT FOUR-WAY INTERSECTION; ILLINOIS TUNNEL CO., CHICAGO.

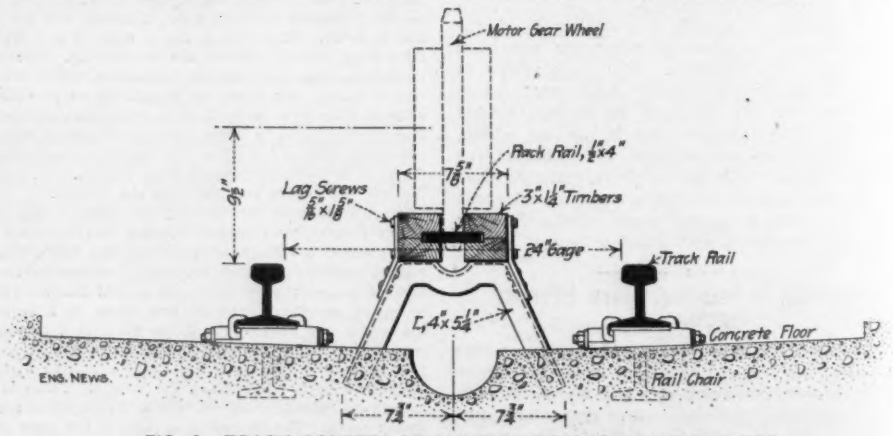


FIG. 3. TRACK CONSTRUCTION FOR CHICAGO TUNNEL LINES.

THE USE OF PULVERIZED COAL FOR FUEL UNDER STEAM BOILERS.*

By J. M. Sweeney, M. W. S. E.†

Of recent years, and particularly with the progress of the manufacture of cement pulverizing machines, methods have been so perfected that it may be safely stated that pulverization of most coals, particularly when dried, can be secured within a cost of 10 cts. per ton.

At the present time the methods being experimented upon for the use of pulverized coal as fuel under steam boilers seem to be divided into two classes: One where the material is pulverized in a detached pulverizing plant and the product conveyed to hoppers over feeding machines in front of the boiler, and the other where an independent pulverizing machine is used and discharges its product immediately into the combustion chamber.

As a subdivision of the class first named there seem to be two methods: One where the pulverized coal is fed into a combustion chamber by the use of a circular brush usually made of steel bristles (Fig. 1), and the other where material is fed in by a blast of air or steam. So far as the evaporative economy of these methods is concerned there seems to be but little choice.

*Abstract of a paper read at the meeting of the Western Society of Engineers, Chicago, March 2, 1904.

†Steel Cable Engineering Co., Chicago.

The following table gives a comparison of trials made with pulverized fuel and hand firing:

	Pulverized.	Hand fired.
Water evaporated from 198°.	2,656.5 cu. ft.	3,258.15 cu. ft.
Fuel burned	18,040 lbs.	27,568
Combustible burned	16,146 lbs.	24,674
Steam pressure	129 lbs.	126 lbs.
Chimney draft	5/10-in. water col.	⅝-lbs.
Stack temperature	490°	580°
Factor of evaporation	1.06	1.06
Water evaporated from and at 212°	169,262 lbs.	207,633 lbs.
Fuel burned	18,040 lbs.	27,566 lbs.
Combustible burned	16,146 lbs.	24,674 lbs.
Water evap. per lb. of fuel from and at 212°	9.4	7.5
Water evap. per lb. combustible from and at 212°	10.47	8.4
HP. units developed	204	230
Lbs. fuel per HP. developed	3.6	4.58
Lbs. of combustible per HP. developed	3.2	4.1

The next stage in the undertaking in the use of pulverized coal for fuel under steam boilers concerns the form of furnace best adapted to the economic combustion of the fuel in this form. It is at this point that most of the troubles begin. Where the pulverization is accomplished in a detached machine situated away from the feeding device, the handling and conveying of the pulverized coal in order to place it in the hopper of the stoker is by no means an easy problem, and so far as the writer knows has not been accomplished in a manner satisfactory to the user. The usual plan is through the medium of screw conveyors, or similar means, operating overhead and depending on the gravity of the pulverized fuel to descend from the conveying trough into the hopper of the stoker. Under these conditions great fluctuation occurs in the constancy of the feed supply, which is affected by the humidity of the atmosphere, since the material has an affinity for moisture, causing its rapid absorption, and a resultant stoppage and caking at times in the masses.

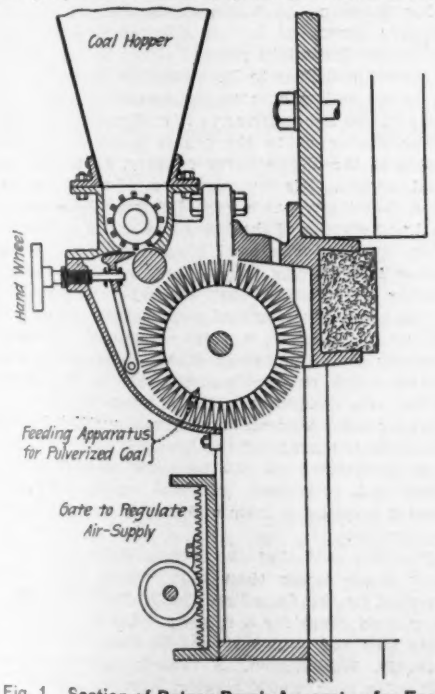


Fig. 1. Section of Rotary Brush Apparatus for Feeding Powdered Coal to a Boiler Furnace.

The usual practice has been after pulverizing the material (in the case of the brush stoker to a fineness of about 100 mesh), to elevate it into a large hopper or tank, this tank feeding into an overhead conveyor, and the material running by gravity from the tank into the conveyor trough. This method practically encounters the caking over of the material in arches in the large hopper and a resultant failure to flow properly into the overhead conveying mechanism.

The fine coal dust finds its way through the slightest openings in any of the retaining parts, and unless the whole of the mechanism employed for this purpose be practically steam tight, the boiler room is soon covered with black coal dust.

So far as these plants have been installed to the knowledge of the writer, it would require more than the economies effected in combustion to offset the very objectionable dirt and trouble which follow the elevation of the material overhead, and seemingly better results might be obtained if the pulverized fuel were not raised any higher than its point of combustion in the furnace. This troublesome feature is to a large extent avoided in the second classification of machines which pulverize and discharge the product immediately into the combustion chamber, but in the record of such machines some accidents have followed their use, which has in some cases been attributed to an explosive mixture formed by the air and powdered coal before it is delivered into the combustion chamber. This condition the advocates of the first method, that of the brush stoker, claim to avoid.

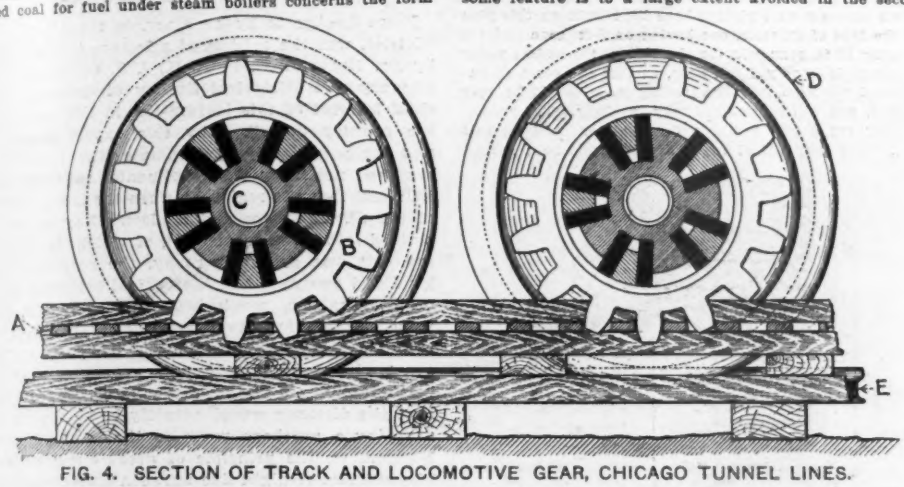


FIG. 4. SECTION OF TRACK AND LOCOMOTIVE GEAR, CHICAGO TUNNEL LINES.

Situated under the brush and in the lower part of the frame carrying the screw mechanism, is a gate operated through rack and pinion (see Fig. 1). This gate regulates the supply of air which goes into the combustion chamber and is mixed with the pulverized fuel after it has left the brush and been projected into the combustion chamber. The combustion chamber is merely a tunnel about 18 ins. wide by some 14 ins. high in the middle of the low sprung arch making its crown. This tunnel is paved with two layers of firebrick and is similar in construction to most of the close joint settings used under boilers. So far, however, this construction has been most unsatisfactory, since it seems to concentrate the combustion into a small zone of fusion which expends itself in the melting of the brick exactly as a blow pipe might be expected to do, rather than in the dissemination of heat units through the absorbing surface of the boiler. This action has resulted in the undoing of the economies found from tests over short runs, where the action has been distributed over a measurable period of practical utility.

An interesting installation is now about to be made by one of the most persistent experimenters along this line, who has found that with the furnace construction just described the costs of maintenance and operation largely overbalanced any gains. They are using two water jacketed combustion chambers to each 72-in. return tubular boiler, these chambers lying under the main shell of the boiler and being brick lined; the water jacket of the combustion chamber being connected directly to the shell of the boiler with the hope of securing a satisfactory circulation. This arrangement is shown in Fig. 2.

When bituminous coal is pulverized for purposes of use in installations of this character, the non-combustible in the coal is pulverized as a part of the mass, and when fed into the combustion chamber, this non-combustible must go somewhere, and seems to be generally deposited back of the bridge wall, or in the flues or between the flues, or upon the tops of the baffle plates, thus requiring very frequent cleaning of these parts of the furnace and boiler, usually developing a loss in evaporative results as these cleaning periods are left behind. Within the knowledge of the writer no installation of this method of firing steam boilers has continued to be used for any appreciable period after its installation, but has been abandoned on various excuses.

Pulverized coal has been and is being successfully used in many cement mills for use in the rotary kilns, but here the byproducts of the combustion pass off with the clinker and go to swell the volume of cement.

The most successful attempt examined into is in the plant of a company producing malleable iron, where fuel in this form is used for the annealing furnaces, and also under the boilers. The installation is a subdivision of the first class, that of a steam jet and an air blast combined for the feeding of the fuel. Fairly satisfactory results are obtained in the annealing ovens, and the system has been continuously used for about three years.

In the application under the boilers, which are of the standard externally fired return tube type, a very large combustion chamber is used, covering the whole of the space from the bottom of the boiler to what would be the bottom of the ash pit in the ordinary setting, and of a width somewhat in excess of the diameter of the boiler shell, the length being about equal to the usual length of grate bar, an arch being turned from side wall to side wall, the crown of the arch against the bottom of the boiler in order to protect the shell from the very intense heat in this large combustion chamber. Here much of the blow pipe effect is lost, but after several years' trial under the boilers at this establishment, it is conceded that the excess cost of the furnace maintenance overbalances the economies resulting from this form of combustion.

SPECIFICATIONS FOR PIG-IRON AND IRON CASTINGS.*

By Robert Job,† M. Am. Inst. Min. E.

Up to five years ago the pig-iron used by the Philadelphia & Reading Ry. Co. had been obtained solely upon the appearance of the fracture, but as the service was unsatisfactory, an investigation was made to determine the quality best adapted to the requirements of the company. It was found in the first place that the proportions of phosphorus and of silicon were high, which resulted in the castings having a rather low tensile strength and being weak under impact. After a study of the quality and conditions of the scrap of the company, as well as of the service desired, specifications were drawn up substantially in the form of those herewith appended, limiting the proportion of phosphorus to 0.5%, and the proportion of silicon to about 1.5%, holding the latter component in practice to about 1.75% also, as some of the scrap was rather high in sulphur, a minimum of 0.4% was placed on the manganese-content of the pig-iron, and ferro-manganese was used in the ladle. The result of these changes was to produce a tough close-grained, easily-machined casting of high resistance under impact.

By the end of the first year after beginning to use this iron, the breakages had decreased to such an extent that the company's supply of scrap was largely cut off, and by the end of the second year the supply had decreased to so low a point that it became necessary to get the scrap for the cupola furnaces elsewhere, and to purify it by an additional treatment.

SPECIFICATIONS FOR IRON CASTINGS (PHILADELPHIA & READING RY. CO., ADOPTED FEB. 24, 1903).

(1) PHYSICAL REQUIREMENTS.—All castings must be of uniform quality, and of solid iron free from physical defects and excessive shrinkage strains, finished in a workmanlike manner, free from sand, and in close accordance with drawings. Castings purchased under Class 1 or Class 2 must be of gray iron throughout and easily machined.

(2) CHEMICAL REQUIREMENTS.—Class 1. Medium Iron.—Engine cylinders, gears, wheel centers, smoke stacks, etc. The iron must be close grained and tough.

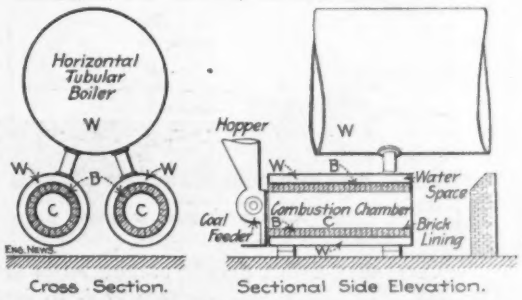


Fig. 2. Water-Jacketed Combustion Chambers for Burning Powdered Coal.

The composition must be silicon, from 1.4 to 2; sulphur, not exceeding 0.085; manganese, not exceeding 0.7; phosphorus, not exceeding 0.6%.

Class 2. Soft Iron.—Small castings for general car and roadway use. The composition must be silicon, from 2 to 2.8; sulphur, not exceeding 0.085; manganese, not exceeding 0.7; phosphorus, not exceeding 0.6%.

Class 3.—Brake-shoes and other castings for frictional wear.—The iron must be hard and tough. The composition must be silicon, from 2 to 2.5; sulphur, not exceeding 0.15; manganese, not exceeding 0.7; phosphorus, not exceeding 0.7%.

(3) METHOD OF INSPECTION.—Upon receipt of a shipment, a thorough inspection will be made, and only those castings will be considered which meet the requirements of Section 1. From such castings borings will be taken from at least one in each fifty or fraction thereof, and the composition must be within the stated limits or the shipment will be rejected.

(4) REJECTED MATERIAL.—All rejected material will be returned at the expense of the shipper, and all castings which fail in service owing to defects of manufacture must be replaced free of cost.

*A paper read at the Atlantic City meeting of the American Institute of Mining Engineers.

†Chemist, Philadelphia & Reading R. R., Reading, Pa.

SPECIFICATIONS FOR PIG-IRON, SUPERSEDING PREVIOUS SPECIFICATIONS (PHILADELPHIA & READNG RY. CO., ADOPTED FEB. 24, 1903).

(1) PHYSICAL REQUIREMENTS.—Shipments must be of uniform quality, and free from sand, dirt, slag, or other foreign matter. Pigs must be broken, or be of such size as to be easily handled.

(2) METHOD OF SAMPLING.—Upon inspection, three pigs will be selected at random from each carload or fraction thereof, and a sample of drillings obtained by boring into the face of a fractured end of each of the three with a blunt, wide-angled 2-in. drill, to a depth of not less than 2 ins., care being taken to have the drillings uniformly fine and free from sand or other foreign matter. The samples from these three pigs will then be thoroughly mixed, and this final sample upon analysis must conform to the following composition, or the carload represented will be rejected.

(3) CHEMICAL COMPOSITION.—The chemical composition must be silicon, from 1.5 to 2.5; manganese, from 0.4 to 0.75; phosphorus, not exceeding 0.50; sulphur, not exceeding 0.04 per cent.

(4) REJECTION.—In case of rejection at the shops, the material will be returned at the expense of the shipper.

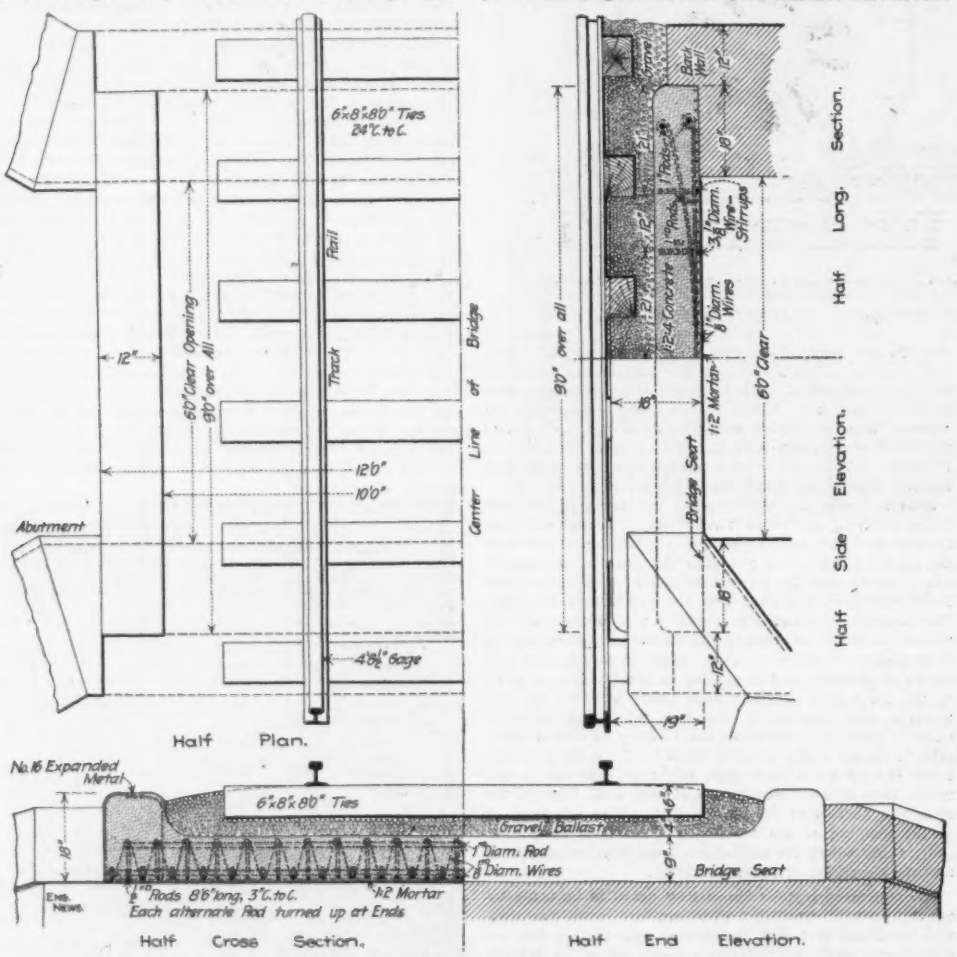
THE DESIGN OF REINFORCED CONCRETE BEAMS.*

Your committee wishes to confine its report to the theory and design for reinforced beams having a rectangular cross-section, and subject to flexure in one direction only. Such beams have been tested, and a theory has been evolved by M. Considère in France, which has been revised and improved by Prof. Hatt in this country. This theory agrees quite well with experiments made under certain conditions favorable to the theory, whereas under other conditions of loading and design the theory does not apply; in fact, it is a question if the theory of flexure should apply to such cases; or, instead, some new theory which will have to be evolved. In some reinforced beams recently tested, in which the span was short, as compared with the depth of the beams, the metal reinforcement would pull out at the ends, and, at the same time, the beams would fail by shearing without bringing any apparent strain on the metal. In comparing these tests with others made at the same time, in which the span was long, as compared with the depth, in which the metal developed its full tensile strength without slipping, it was suggested that if the metal reinforcement in a beam could in some way be prevented from pulling out at the ends, it would be possible to design a beam of any depth which, upon testing to destruction, would fail by giving way on the tension face. In order to accomplish this, all that was necessary was to anchor the rods at the ends of the beam, when the full tensile strength of the metal could be obtained every time, provided the percentage of metal used did not exceed certain limits. It should be explained that the rods used in all cases were plain rods of medium open-hearth steel, obtained from stock in the open market, and the only requirement to be filled was that they should be capable of bending cold around a radius equal to the thickness of the bar.

Two concrete-steel girders have been built on this plan for the tops of culverts, one having an 8-ft. span and the other an 18-ft. span. In the short span, the ballast under the cross-tie is only 4 ins. deep, so that the effect of impact and vibration from the moving loads should be very marked, and will be watched very carefully. The accompanying cut shows a design for a girder built on this plan. The longitudinal rods have the ends bent around a transverse rod, the latter forming the anchorage. This is done in the field by bending the rods cold around the nose of an ordinary blacksmith's anvil. This does not require skilled labor, and the lengths of the rods, center to center of eyes, need not be made exact, as the mortar fills up all open spaces in the eyes. It should be explained that the transverse anchor rods serve a double purpose. In addition to their value as an anchorage they are intended to serve as a bond between the longitudinal sections of the concrete, when it becomes necessary, for practical reasons, to lay the concrete in sections, as is usually the case, instead of in one piece.

As to the theory of concrete-steel beams reinforced in this manner, we understand that the entire subject of concrete-steel will be taken up by a committee to be appointed by the American Society of Civil Engineers. This committee will probably have the means to make some tests which will enable them to establish a satisfactory theory, and, as they will co-operate with any other committee working on this subject, we suggest that your committee be instructed to co-operate with them as soon as their committee is appointed.

In the meantime, we recommend that the theory for concrete-steel beams as given by Professor W. K. Hatt be used. (See Engineering News, July 17, 1902). In order to avoid the tedious computations necessary to design a beam with this theory, we recommend that graphical diagrams be used as given in Engineering News, April 30, 1903.



CONCRETE-STEEL GIRDER BRIDGE WITH END ANCHORS FOR REINFORCING RODS.
Designed by J. W. Schaub, M. Am. Soc. C. E.

Assumed fixed load = 1,950 lbs. per lin. ft.
Assumed moving load = 62,500 lbs. on one axle.
D indicates fixed load stress.
L indicates moving load stress.
I indicates impact stress = $I = L \times \frac{L}{L+D}$.

Material is proportioned so as to give a factor of safety of 3 inside the elastic limit of the material, including allowance for impact.

M_D = 11,900 ft.-lbs.;	S_D = 6,830 lbs.;
M_L = 54,800 "	S_L = 62,500 "
M_I = 45,000 "	S_I = 56,300 "
ΣM = 111,700 ft.-lbs.	ΣS = 125,630 lbs.

*Abstract of a report prepared by the Committee on Masonry for the annual meeting of the American Railway Engineering and Maintenance of Way Association; Committee: E. C. Brown, John Dean, W. L. Breckenridge, C. W. Boynton, A. O. Cunningham, C. Lewis, J. W. Schaub, G. F. Swain and W. D. Taylor.

CONCERNING THE PROJECTED NORTHERN CANADIAN TRANSCONTINENTAL RAILWAY.

From Quebec to Peace River, in the Athabasca District, was the subject of a lecture lately given by Dr. Robert Bell, F. R. S., I. S. O., before the Literary and Historical Society of Quebec. The chief interest of this lecture lies in the fact that the country described by this expert geologist and engineer closely approximates the line of the proposed northerly transcontinental railway. Dr. Bell said that the region between the Great Lakes of the St. Lawrence and Hudson's Bay could be divided into three great belts, of which the southern belt was generally rocky, the northern belt level and swampy, and the central belt was, generally speaking, much better in character and most suitable for development by a railway. A railway in this central belt would also have the great advantage of a very low grade, or a grade best adapted to a line of heavy traffic. He showed that the distance would actually be shortened by adopting a northern route to the head of Lake Nipigon, on the principle of great circle sailing. The nominal straight line between Quebec and the head of Lake Nipigon would really be 1,053 miles long, as against 810 miles by the northern route suggested. Making all deductions for the deflection of the arc, there is still an advantage of at least 220 miles in favor of the "curved" line, to say nothing of the much cheaper construction in this comparatively level region.

For the region west of the outlet of Lake Winnipeg, Dr. Bell was disposed to favor a route running between the North Saskatchewan and the Beaver River, as far as Edmonton. From this point the line might proceed either by way of the Yellow-Head Pass to Bute Inlet on the Pacific, or it might follow a more northwesterly course by way of the Peace River to Port Simpson. He had some doubts as to the praise lavished upon all parts of the Peace River country, as to fine soil and climate. His investigations led to the conclusion that there was a vast difference between the soil and climate of the lower and upper sections of this country. The good climate and soil of the lower Peace River extends in a north and south rather than in an east and west direction; it crosses the river named rather than follows it. There is, therefore, a great stretch of promising country between Lesser Slave Lake and Great Slave Lake, on the western side of the Slave River. On the contrary, in the upper Peace River country some sections lie as much as 800 ft. below the general surface of the country; and what has been considered as soil by some observers is a hard and undrained material overlaid by the merest covering of loam and utterly unsuitable for cultivation.

Dr. Bell said that the Yellow-Head Pass was very much lower than that which has been adopted by the Canadian Pacific Railway, and a very good route for a railway from this point to Bute Bay had been surveyed 25 years ago by the late Mr. Waddington. A branch railway, about 400 miles long, would connect Fort Victoria, near Edmonton, with Fort Smith, on the Slave River. At the latter point occurs the only obstruction to navigation on the Athabasca-Mackenzie River, all the way to the Arctic Ocean. A railway at this place would, therefore, connect with the navigable waters, both above and below the obstructing rapids, and render a vast region tributary to the railway, and the latter would itself traverse a very fine agricultural country.

TABLE I.—SEA STRENGTH OF THE PRINCIPAL NAVAL POWERS; NUMBER AND DISPLACEMENT OF WAR-SHIPS, BUILT AND BUILDING, OF 1,000 OR MORE TONS DISPLACEMENT.

TYPE.	Great Britain.				France.				Russia.				Germany.				United States.				Italy.				Japan.				Austria.			
	Built.	Tons	Building.	Tons.	Built.	Tons.	Building.	Tons.	Built.	Tons.	Building.	Tons.	Built.	Tons.	Building.	Tons.	Built.	Tons.	Building.	Tons.	Built.	Tons.	Building.	Tons.	Built.	Tons.	Building.	Tons.	Built.	Tons.	Building.	Tons.
Battle-ships, first class*	50	699,000	9	142,600	20	295,621	6	87,800	17	201,129	8	113,864	14	152,581	6	77,988	11	125,129	11†	168,700	14	173,276	5	69,155	6	84,300	..	.....	..	.....	3	31,800
Other battle-ships and coast defence ironclads	6	49,900	..	.....	20	94,515	..	.....	19	66,579	..	.....	16	90,775	..	.....	12	47,945	..	.....	8	12,344	..	.....	3	13,004	..	.....	11	62,480	2	16,720
Armored cruisers	27	262,900	14	166,000	15	113,767	8	91,549	6	71,361	..	.....	3	28,144	3	28,046	2	17,415	8	111,800	5	31,891	1	7,264	8	73,550	..	.....	2	11,500	1	7,400
Protected cruisers, first class (above 6,000 tons)	21	201,950	..	.....	4	31,513	..	.....	6	39,346	3	19,965	..	.....	..	.....	2	14,750	3	28,800	..	.....	..	.....	..	.....	..	.....	..	.....	..	.....
Protected cruisers, second class (3,000 to 6,000 tons)	53	235,880	7	21,000	19	79,752	..	.....	5	19,450	3	9,445	9	46,949	..	.....	15	56,398	4	12,400	5	17,490	..	.....	10	41,296	3	10,005	2	8,138	..	.....
Other cruisers and scouts (above 1,000 tons)	44	96,510	8	21,510	18	32,840	..	.....	11	18,000	..	.....	31	60,437	4	11,715	23	32,773	2	2,170	11	23,987	..	.....	17	31,506	..	.....	6	11,785	..	.....
Totals	201	1,516,040	38	351,210	96	676,108	14	179,349	59	415,155	14	142,274	73	387,874	13	117,745	65	294,405	28	321,870	38	258,838	6	70,419	44	243,586	3	10,005	21	93,913	6	55,920
Combined totals	239 of 1,867,250 tons.				110 of 755,757 tons.				73 of 557,429 tons.				86 of 505,619 tons.				93 of 616,275 tons.				44 of 329,257 tons.				47 of 253,681 tons.				27 of 149,833 tons.			

* Battle-ships, first class, are of (about) 10,000 tons, or more, displacement, and are not more than 20 years old. The few exceptions as to age have been reconstructed and are given a modern armament.

† Contract not yet awarded for two additional authorized.

N. B.—Gunboats and other vessels of less than 1,000 tons are not given in the table, nor are transports, despatch vessels, converted merchant vessels or yachts, or obsolete cruisers. Vessels not begun are not included in the table.

SEA STRENGTH OF THE CHIEF NAVAL POWERS.

The accompanying tables are based upon data issued by the U. S. Office of Naval Intelligence, and they give the number and displacement of war-ships, built and building, of 1,000 or more tons displacement, the number of torpedo boats and submarines, and the relative order of warship strength. The last table shows that with the ships completed that are now building, the United States moves from the fifth to the third place in the list of naval powers.

A MEMORIAL STATUE TO JAMES WATT.

A statue of James Watt, the great inventor, is to be erected at Greenock, Scotland, on the site of the humble cottage in which Watt was born. Subscriptions of small amounts for this purpose are being solicited in many countries, as it is felt that the memorial should represent the contributions of the thousands who know and appreciate what the invention of the steam engine has meant to the material progress of the world. An American committee has been formed to receive contributions of $5 or less, and from American engineers for this purpose, and is composed of the following gentlemen:

Andrew Carnegie, Chairman.
Albert R. Ledoux, President, American Institute of Mining Engineers.
Ambrose Swasey, President, American Society of Mechanical Engineers.
Charles Hermany, President, American Society of Civil Engineers.
Bion J. Arnold, President, American Institute of Electrical Engineers.
Charles F. Scott, Westinghouse Electric Manufacturing Company.
John H. Converse, President, Baldwin Locomotive Works.
Charles Allis, President, Allis-Chalmers Co.
C. W. Hunt, President, C. W. Hunt Co.
S. R. Calloway, President, American Locomotive Co.
R. A. McKee, International Union Steam Engineers.
John C. Kafer, Engineers' Club, New York.
J. D. Farasey, American Boiler Manufacturers' Association.
C. L. Salmons, Brotherhood of Locomotive Engineers.
J. J. Hannahan, Brotherhood of Locomotive Firemen.
W. J. Gitthorpe, Boilermakers and Iron Shipbuilders of America.
C. L. Shamp, International Brotherhood of Stationary Firemen.

Subscriptions should be forwarded to Mr. Theodore Dwight, Secretary and Treasurer of the Committee, 99 John St., New York City, who will acknowledge them and forward a slip for the contributor's autograph, as the autographs of the various contributors are to be forwarded to Greenock.

THE UNION ENGINEERING BUILDING in New York City is to be built, notwithstanding the decision of the American Society of Civil Engineers not to join the other Engineering Societies in its occupancy. It will be remembered that some months ago Mr. Carnegie increased his original offer of one million dollars for the building to one and one-half millions, on the supposition that a larger building than that originally planned would be required to accommodate the Civil Engineers. He has now agreed to give the larger sum, notwithstanding the withdrawal of the Civil Engineers from the proposed co-operation. His written offer is as follows:

2 East 91st St., New York.
March 14th, 1904.

Gentlemen of the American Society of Mechanical Engineers; American Institute of Mining Engineers; American Institute of Electrical Engineers; Engineers' Club of New York:

It will give me great pleasure to devote, say, one and a half million of dollars for the erection of a suitable Union Home for you all in New York City. With best wishes, truly yours, (Signed) Andrew Carnegie.

It is said to be probable that besides the societies named, arrangements will be made whereby the building will be used for offices and headquarters by several other engineering and technical societies. The great technical library proposed in an editorial in our last issue is also likely to be a feature of the building, the existing libraries of the several societies serving as a nucleus, which already amounts to nearly 50,000 volumes. The land for the building, it will be remembered, has already been acquired for the societies by Mr. Carnegie. The committee in charge of the enterprise representing the several societies interested, is made up as follows: American Society of Mechanical Engineers—Prof. F. R. Hutton, C. Wallace Hunt, J. M. Dodge. American Institute of Mining Engineers—Dr. A. R. Ledoux Theodore Dwight, C. Kirchhoff. American Institute of Electrical Engineers—C. F. Scott, Dr. S. S. Wheeler, Bion J. Arnold. The Engineers' Club—J. C. Kafer, W. H. Fletcher, T. C. Martin.

THE CONTRACTS for the construction of the Pennsylvania R. R. tunnels under the East and North Rivers were awarded this week in New York City. The contract for the North River tunnel was given to the O'Rourke Engineering & Construction Co., an organization of which Mr. John F. O'Rourke, M. Am. Soc. C. E., is President, and which already has the contract for constructing the new terminal for the New York Central R. R. at 42d St.

The contract for the tunnels under the East River was awarded to the English firm of S. Pearson & Son, which has had an extensive experience in difficult subaqueous tunneling work. It built the Blackwall tunnel under the Thames in London and did considerable work on the North River tunnel a dozen years ago.

THE HUDSON RIVER TUNNEL, from the foot of 15th St., in Jersey City to the foot of Morton St., in New York City, was holed through on March 11, 1904. This tunnel was first started in 1874, and work was continued intermittently until 1882, when about 2,000 ft. of the northernmost of the two parallel tubes had been completed. Later work was resumed by the well-known English contracting firm of S. Pearson & Sons, but owing to lack of funds to pay for the work, it was abandoned again in 1891. At the time work was abandoned about 3,895 ft. of the north tube had been completed. In 1902 the New York & New Jersey R. R. Co. was organized to complete the tunnel, and work was begun under the direction of Messrs. Jacobs & Davies, Engineers, of New York City. Work was concentrated on the north tube, and it is this tube that was completed on March 11. A description of this work will be given in a future issue.

A LARGE LAKE STEAMER is soon to be launched at Lorain, O. The vessel will be 560 ft. long over all, 56 ft. wide and 32 ft. deep, with a draft, loaded, of 18½ ft. The vessel, to be called "A. B. Wolvin," is intended for the ore-carrying trade, and is arranged with special reference to the use of automatic unloading machinery. The gross tonnage of the vessel is 10,000. This is believed to be the largest steamer on the Great Lakes.

TWO DOUBLE STEAM-TRUCK LOCOMOTIVES, on the Meyer system, have been built by Kitson & Co., of Leeds, England, for the Rhodesian Railways (3 ft. 6 ins. gage) in South Africa. They are for heavy freight service, and are designed to haul a train load of 624 tons (behind the tender) at 8 miles an hour up grades of 1½%, with a curve of 660 ft. radius on the grade, and the engine working under 75% cut-off. The leading six-wheel truck is under the smokebox and front end of the boiler, but has its cylinders at the rear end of the frames. The other six-wheel truck is under the cab, and a rear tank and coal bunker, with cylinders at the rear end of the frames and with an exhaust stack carried up behind the cab. A double truck tender is attached to the engine. The principal dimensions are as follows:

Driving wheels	4 ft. 0 ins.
Wheelbase, truck	8 " 6 "
Wheelbase, total	34 " 0 "
Weight of engine, loaded	72 tons.
Weight of tender, loaded	42 "
Cylinders (4)	16 × 24 ins.
Boiler, diameter	5 ft.
Boiler, rail to center line	7 ft. 2 ins. 5 "
Working steam pressure	180 lbs.
Firebox, length	8 ft. 3 ins.
Tubes, length	13 " 4 "
Heating surface, tubes	1,590 sq. ft.
" " firebox	136 "
" " total	1,726 "
Grate area	34 "
Engine bunker	3 tons.
Tender, coal capacity	7 "
Tender, water capacity	2,835 galls.
Height, rail to top of smokestack	12 ft. 10 ins.

THE LUCIN CUT-OFF CROSSING over Great Salt Lake, Utah, is still giving trouble. According to a news dispatch a freight train going over the crossing a few days ago was delayed because of settlement of a part of the line. The last sinking spell of the crossing occurred five or six weeks before. No passenger trains will be sent over the cut-off for some time, according to this dispatch. No statement of the difficulties encountered in this work has yet been given out by the railway officials.

DAMAGES FOR A DEFECTIVE SEWERAGE SYSTEM are claimed against the city of Para, Ill., it is reported. The claimant is Mr. Andrew O. Proffitt, who alleges that defects in the sewerage system caused the death, about a year ago, of his wife and two children. It is expected that the suit will come to trial within a few weeks.

TABLE II.—Number of Torpedo Vessels and Submarines, Built and Building.

TYPE.	Great Britain.		France.		Russia.		Germany.		United States.		Italy.		Japan.		Austria.	
	Built.	Building.	Built.	Building.	Built.	Building.	Built.	Building.	Built.	Building.	Built.	Building.	Built.	Building.	Built.	Building.
Torpedo-boat destroyers	135	21	25	13	49	9	32	12	16	.....	11	2	19	..	7	..
Torpedo boats	90	.....	200	30	165	5	93	..	30	4	142	8	67	18	61	..
Submarines	9	10	30	10	1	..	....	3	8	.....	1	2	..	..	1	..
Totals	234	31	315	53	215	14	125	15	54	4	154	12	86	18	69	..
Combined totals	265		368		229		140		58		166		104		69	

TABLE III.—Relative Order of Warship Strength.

At present.		As would be the case were vessels building now completed.	
Nation.	Tonnage.	Nation.	Tonnage.
Great Britain	1,516,040	Great Britain	1,867,250
France	576,108	France	755,757
Russia	416,158	United States	616,275
Germany	387,874	Russia	558,432
United States	294,405	Germany	505,619
Italy	258,838	Italy	329,257
Japan	243,586	Japan	253,681
Austria	93,913	Austria	149,833

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Entered at the New York Post-Office as Second-Class Matter. Published every Thursday at St. Paul Building, 220 Broadway, New York, by

THE ENGINEERING NEWS PUBLISHING CO

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE, 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; *6 months,* $2.50; *10 weeks,* $1.00. *To all other countries in the Postal Union: Regular Edition. One Year,* $8.00; *Thin Paper Edition, One Year,* $6.75. *SINGLE COPIES of any number in current Volume,* 15 *cents.*

In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 325 *means that subscription is paid to the* 32d *week (that is the issue of Aug.* 10) *of the year* 1905; *the change of these figures is the only receipt, unless one is sent by special request.*

ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see pages* 26-27. *New copy for standing advertisements should be received ten days in advance of publication; new advertisements, Monday morning. The pages containing "Want" advertisements are held open until Tuesday, and those with "Proposal" and "For Sale" advertisements until Wednesday at* 11 *a. m.*

The collapse of the Darlington building in New York City has started anew the discussion as to where the responsibility should be placed for the safe construction of buildings and other structures. As usual, there is a general appeal for a revision of the building laws and for a Building Department with summary powers of control.

Doubtless the building laws could be improved, and doubtless also some of the red tape with which the procedure of the department is hampered might be eliminated; but is the building law or the Building Department properly chargeable with the main burden of responsibility for such disasters as that at the Darlington? Is it not a fact that the primary responsibility for the safety of a building is, or ought to be, with its owner? The purpose of the building law and those who administer it, is not to relieve him, or the architects and engineers whom he employs, from one particle of their responsibility for safe and sound construction. It is the business of the owner to employ competent architects and engineers to design and supervise his work, and honest contractors to execute it; and it is with these parties that the real responsibility for safe work must lie, because *they do the work.* It is wholly out of the question for a city building department to examine and pass upon each and every detail in connection with the erection of a building, as it would have to do if the primary responsibility for safety were placed upon it.

We believe it is worth while to lay emphasis upon this fact because an idea is abroad that the building law and the Building Department have relieved owners and architects and engineers of their ordinary responsibilities in the matter of safety. If a man is to erect a building out in the country, he and those who he employs understand perfectly that it is their business to make a building which will withstand winds and storms and loads, and that each and every part of the building must be properly proportioned to do its work. This is as it should be; but when the building is to be erected in a great city, where building is carried on under official supervision, we fear that too frequently the owner instructs the architect to design the cheapest structure that the Building Department will pass. With these instructions from the owner, naturally the ingenuity of the architect and engineer and contractor is diverted from attention to safe design and construction to the endeavor to make the lightest and cheapest structure that will comply with the law.

In the past half century there has been a general movement toward the establishment of state and municipal and national supervision over matters which concern public safety. This is a necessary and commendable departure, and we say no word to oppose it. What we do wish to point out is that all this supervision by public officials should never operate to relieve or relax the responsibility of those who actually do the work.

The principle is broader by far than the mere matter of municipal building inspection. Massachusetts, for example, has established supervision of the safety of bridges used by railways; but it is none the less the duty of the railway companies to employ engineers competent to design safe bridges and contractors competent to construct them. The engineer and contractor, too, should be just as careful and thorough as if no state inspection existed.

The United States Government inspects marine boilers; but it is as much the duty of the builder of a steamship to build boilers safe in every respect and to know that they are safe as it would be if no law and no inspection existed.

Many cities have, very properly, an inspection of elevators; but the owner and engineer of a building in which elevators are used who takes less care to provide for their safety because of such inspection, is trifling with danger.

In thus pointing out that the primary responsibility for safe construction must be placed upon the owner, we do not forget that conditions in the large cities tend to make the owner in too many cases heedless of his responsibility, and that this is one reason why large responsibilities and large powers must be given to the Building Department.

Much of the building in New York and other large cities is done on speculation. The nominal owner really holds only a lease of the land, or if it is freehold property he covers it with a mortgage and retains only a small equity. The building he erects on a loan payable in installments as the building advances, and his sole chance of profit is to cut down on the cost of construction to the lowest point, rush the building to completion as rapidly as possible, and sell it afterward at an advance over its cost. He will lavish money on the decoration and outside show which help to make the building attractive to tenants and salable, and stint at every point that relates only to construction and safety. Admittedly, the building law is a necessity to set a limit to the tampering with public safety by builders of this class; but even here we must still believe that the primary reponsibility for safe construction must rest with the owner; if not with the nominal owner, then with those who hold the mortgages and advance the money for construction. We trust the fall of the Darlington building may be a warning to the financial institutions who furnish funds for speculative building operations; and that they will be more careful in future to see to it that the structures on which they grant building loans are planned and supervised by competent architects and engineers, whose reputation will be a guarantee of safe and sound construction.

Indications multiply that one of the greatest fields of future work for the engineering profession in America is to be the control and regulation of rivers. In New York, in New Jersey and in Pennsylvania the matter of flood protection is now receiving serious attention. Those who have given attention to the subject are well aware that there is no one remedy applicable to all cases. Each problem must be separately studied and the solution must be found in the construction of dikes and levees, in the deepening of the bed and protection of the banks or in the construction of storage reservoirs for the floods, according to local conditions.

On the Passaic River, which did such destruction in Paterson last fall, the Northern New Jersey Flood Commission has just reported in favor of the construction of a $3,000,000 dam at Mountain View to impound part of the run-off from the steep water-sheds of the northern tributaries of the Passaic. This reservoir would cover nearly a square mile of territory. While its cost would be great, the commission estimates that the damage done by the flood of last fall amounted to not less than $7,000,000.

On the Susquehanna River, damage by floods this spring is estimated in the press reports at not less than a million dollars. In the New York legislature a bill for a State Flood Commission is now pending, and is said to be receiving general support.

It is worth while pointing out in this connection that when the control of floods in rivers is taken up in earnest, some important questions of the respective rights of adjoining states to the control of waters will have to be settled; and it may even be necessary for the National Government to take charge of the work, as it already controls the navigable streams of the country. The flood waters which have recently caused such destruction on the Susquehanna, for example, largely originated across the boundary in New York; and it is quite possible that when the problem of protecting cities and towns in Pennsylvania from flood damage is seriously taken up, it may be found advantageous to undertake works in New York.

A new schedule of official regulations concerning railway construction in China has been issued by the Chinese government, and a translation is published in the U. S. Consular Reports of March 3. A careful reading indicates that the regulations have been framed with not a little intelligence and sound statesmanship.

For one thing it is required that all new railways must have the standard gage of "exactly 4 ft. 8½ ins.," the same as that of roads now in operation. Had a similar ruling been put in force by the Government of British India, or of Australia many years ago, it would have saved the vexations attendant upon the present variety of gages. Even in the United States it is only a few years ago that cars were running in interchange traffic over roads having gages all the way from 4 ft. 8½ ins. to 4 ft. 9 ins.

Of course it is true that the Chinese are profiting by the experience of other countries, and the demonstration of the fallacy of the narrow-gage idea; but it is a notable fact that even in the countries of highest civilization it takes a long time for improvements in engineering practice made in one country to be adopted in another.

Another idea which only a few of the most progressive states in this country have adopted, is the restriction of railway projects to such as are really meritorious. Article XVI of the regulations requires that all projected lines shall be reported upon by the provincial viceroys or governors, as to "whether or not the proposed road will really be of advantage to Chinese commerce or transportation."

Still another meritorious idea is a limitation of the life of concessions. Article XIII provides that surveys must begin within six months and construction within one year after granting the concession. If this limit of time is exceeded and no report is made to the railway board, the concession is cancelled. Provision is made, however, for an extension of time by the Official Board in case sufficient cause for the delay is established.

Article XIV and XV are of such special interest, particularly to engineers who may consider going to China for employment, that we give them in full as follows:

Art. XIV. If at any place in any of the Provinces where railways are in construction landowners shall raise the price of land, thus hindering or causing trouble, or if workmen, depending upon numbers, shall constitute a boycott (i. e., probably in order to secure unreasonable wages), it will be permitted the company to make a clear report of the matter to the local authorities, who shall issue a strict proclamation, suppress the disturbance, and prohibit, under severe penalties, all extortionate practices of yamen underlings. It must be known that railways are the foundation of commercial prosperity and profitable transportation, as well as an important enterprise of the Imperial Government. If the said local officials prove unable to give protection and evade their responsibilities, on investigation, if the facts be as reported, they shall be impeached and dismissed.

Art. XV. At present such experts as are needed in surveying for railways, estimating their cost, and superintending the construction are few in China, and it be-

names necessary to permit the companies to engage foreign officers, and the local authorities of the places through which they may pass or where they are temporarily residing must use extra care in giving them protection; they must not allow the least unforeseen danger to arise. If the said foreign officers are themselves unmindful of the properties and set social restraints at defiance, it is permitted the local authorities to notify the company so that they may be discharged. They must not be screened and protected improperly by being transferred to some other road to be employed. If their faults be serious it is permitted to report them to this board, which shall transmit the complaint to the various consuls concerned. They shall not be allowed to travel or reside in China.

The moral of Article XV. would appear to be that the engineer who is prone to be "unmindful of the proprieties" and to "set social restraints at defiance" had better seek employment in some other country than China.

As for the excellent provision against extortionate changes for "right-of-way," in Article XIV., we apprehend that not a few American right-of-way agents will register a wish that it were possible to threaten with the Chinese penalties some American landowners who take advantage of their opportunity to exact a high price for their property, knowing that the company will submit to the exaction rather than incur the cost and delay of condemnation proceedings.

Further restrictions as to the right of way are given in Article IV., which states that:

> When a line of any railway shall have been surveyed and agreed upon, the local officials must first notify the people, so as to prevent any intentional obstruction. As to the purchase of the ground by the company, the local officials must fix a fair price; they must not allow any raising of the price.

The matter of Chinese graves is also brought forward in the same article, and it is stipulated that:

> Whenever any cottages or graves are found in the line of the railway, if they can be avoided by a curve, steps must be taken to do so, in order to satisfy popular sentiment. If it shall be very difficult for the railway to go around them, the local officials shall decide what payment shall be made for them, so as to prevent contention and obstruction.

One further notable feature of the regulations is the requirement that Chinese capital shall hold the controlling interest in Chinese railways. The regulations are apparently designed to destroy the business of the speculative concession hunter and confine railway development to legitimate and honestly managed enterprises controlled by home capital. It is specified in Article VI. that the Chinese-owned shares in any company must be in a majority and that even in the case of concessions granted to foreigners (which, it is hinted, are not likely to be looked upon with favor), the promoters "must reserve 36% of the shares and allow the Chinese opportunity to purchase these shares at the original price." Raising money by bonds for original construction is practically prohibited, the only exception being that a company in financial difficulties may raise money by mortgaging its buildings and machinery, but not its lands. The grant of a concession is made void if its holders attempt to borrow foreign money by an issue of mortgage bonds, except under the conditions above specified.

From time immemorial, as the expression goes, water-works superintendents have endeavored to educate their patrons out of the habit of keeping faucets running to prevent pipes freezing in cold weather. It has been urged very properly that the plumbing inside a house should be so arranged and protected as to be safe from freezing, and that the careless property owner who does not do this should be made to pay for the water he permits to run to waste to prevent his pipes from freezing.

But this exceptional winter of 1903-4 has created a new situation. The frost has in many sections penetrated to a greater depth than has ever before been known. In many places it has gone below the level of house service pipes and even street mains. Instead of warning water users against the waste of water to prevent freezing, some water-works superintendents have been forced to issue requests to keep a small stream running from one faucet in each house as the only alternative to the freezing and damage of both mains and services.

It may be said that the lesson to be learned is that water mains and services should be laid at greater depth; but it is not at all certain that this would be wise, save where trouble has been experienced in other winters. Every inch increase in the depth of trenches for water pipes adds to the cost of laying them; and it would be cheaper to let some water run to waste in an occasional especially severe winter than to incur the great expense involved in laying all new water pipe to a lower grade. As for lowering the level of the mains and services now in existence, that is, we hardly need say, a practical impossibility.

THE PROTECTION OF FIREPROOF BUILDINGS AGAINST EXPOSURE FIRES.

Modern fireproof building construction may be considered to have received supreme test in the Baltimore conflagration of Feb. 8 and 9, and in the small but equally destructive fire which occurred at Rochester, N. Y., on the 25th and 26th of the same month. Perfect success and absolute failure have both been claimed as the outcome of this test. Obviously both verdicts cannot be true. It is equally obvious, also, to everyone who studies the evidence, that the complete success of the fireproof building was not demonstrated and neither was it shown that this modern form of construction is a failure. Just where between these two extremes the final decision will rest is a matter of pure speculation until time has corelated and integrated the accumulated facts and proved the accuracy of the result.

In reviewing the effects of the Baltimore and Rochester fires as they are recorded in this and preceding issues of Engineering News, two facts stand out prominently. The first is that from the point of view of the tenant, the tall fireproof buildings which went through the flames, were just as complete a failure as were the combustible structures which surrounded them. The second fact is that from the point of view of the owner, the fireproof building leaves him from 60 to 75 percent. salvage on the total cost, while the combustible structure is a complete loss. In both the Baltimore and the Rochester fires every tenant of a fireproof building lost the entire contents of his premises and the disaster could have been no greater had he occupied a timber shanty; in the same fires every owner of a fireproof building can put his property in its original condition by spending from 25 to 40 per cent. of its first cost in repairs, while if he had owned a non-fireproof structure he would have been compelled entirely to rebuild it.

If, as was the case in the Baltimore and Rochester fires, the fireproof building offers no safety to its tenant and gives its owner only partial protection from loss, does it pay to build fireproof structures? There is little doubt of the answer that will be made to this question by engineers and architects, but an affirmative reply from the building owner and tenant is not so certain. In fact, the opinion has been publicly expressed a number of times that a return to older standards is desirable. This frame of mind is easily understood and excused under the circumstances, but it should not be encouraged. There are several good reasons for asserting that even under the supreme test of the Baltimore conflagration, the modern fireproof building justified its existence, and it will not be out of place to point them out at this time.

In all that has been said of fireproof buildings in the Baltimore and Rochester fires, reference has been had specifically to the tall steel building with veneer walls and floors and partitions of structural fireproofing. It is this type of building alone that is referred to in the succeeding remarks. Taking the evidence of the Baltimore and Rochester fires, it is plain that if the salvage of from 60 to 75 per cent. of his property from conflagration is worth while to the building owner, then it pays him to build fireproof instead of non-fireproof. The best reason for fireproof construction is not so near the surface, however. It is impracticable, as a structural problem, to construct tall buildings otherwise than with steel frames carrying veneer walls and incombustible floors of terra cotta or concrete. The questions of weight and space alone prohibit self-supporting walls and brick arch floors of the old type. Neither can we substitute wood for terra cotta and concrete, for fire in this case would mean the collapse of the steel structure with results whose mere anticipation would bereave the structure of neighbors as well as tenants. If the tall building is to continue, it must not be built of less fire-resisting construction than it is at present, otherwise it will be a menace, not only to owners and tenants, but to the community in which it exists.

It is almost idle to consider the other alternative of abandoning the tall building. This type of structure meets, as no other can, a condition of business life in modern cities which is becoming more pronounced every year, and no consideration warrants the public in retarding its development except the single one of its menace to the business life which it is designed to subserve. So far as the fire hazard is concerned, the tall building has been at least partly successful, and the task before the business community is to make it still more successful. No other conclusion is warranted by logic and experience.

Is it practicable to make the modern tall fireproof building more sturdy against attack and destruction by fire than it showed itself to be at Baltimore and Rochester? This is a question which permits of almost any length of answer that may be desired, and here the attempt will be made to answer it from one standpoint only. The burning of the tall buildings at Baltimore and Rochester was due to fire contributed from adjoining structures. None of the burned buildings was ignited in any other way than from the outside. If, then, they had been proof against the attack of exterior fires they would have suffered little if any interior injury. Is it practicable to establish this safeguard in tall building construction? If it is, then the experience at Baltimore and Rochester is conclusive evidence that every effort is warranted to establish it.

The example of the 13-story Granite Building, in the Rochester fire, proves, at least, that opportunity exists for improvement in some instances. Here a fireproof building of moderately good construction was connected by clear openings aggregating some 3,500 sq. ft. in area with two combustible structures, one of which was a veritable fire trap. Because of these openings it was practically impossible that the adjacent structures should burn without igniting the Granite Building. Besides these openings, the Granite Building had on the side adjacent to the most dangerous of its neighbors a wall thickly pierced with windows of the ordinary plain glass and wooden sash and casing construction. One does not need to be an engineer or an expert in fire protection to appreciate the danger of such conditions; the only surprising thing is that any sane building owner should allow them to exist.

It may reasonably be asked what remedy was possible in such a case. The only certain one would have been to eliminate the openings; a solid wall would have protected the Granite Building against the exposure hazard. This remedy being impossible the next best thing would have been the reduction of the openings to the smallest possible number and dimensions and to protect them with fire-resisting doors or shutters. It would be rash to assert that this would have kept out fire entirely, but it is quite safe to say that its entrance would have been hindered, the delay being in proportion to the resistance of the doors and shutters to destruction by fire. Anything would have been better than the conditions which existed, and it is not assuming too much, we think, to expect that, by adopting a reasonable compromise in door and window openings and then protecting these openings by means readily available, the destruction in the Granite Building could have been reduced to comparatively moderate dimensions.

In the Baltimore fire we have a different set of conditions than existed at Rochester. Here the tall buildings were attacked on all sides by a storm-borne conflagration, whose size and fierceness has been equalled only a few times in the world's history. It is quite possible that no available form of window protection would have shut out the flames entirely; at least the few isolated examples of shutters which passed through the fire, did not emerge in a condition which says much for their efficiency. It must be remembered, however, that these shutters were attacked

on both sides, owing to the buildings having been ignited from the street windows as well as being attacked from the rear. In a fire like that of Baltimore, safety would have existed only in guarding every window.

Theoretically the guarding of every window by a protective device against fire is an attractive proposition, but the practical problem of designing and applying such a device is not an enticing one, as every architect knows. The familiar double flap hinged shutter is inapplicable to the ordinary tall building facade for lack of room, even were building owners and architects willing to deface their structures with such devices. The only alternatives are some form of rolling shutter which is concealed from view except when closed or else the use of some fire-resisting form of window construction and glazing. Mechanically, the rolling shutter is a simple enough device to design and apply, but none of those that have been designed seem likely to have much sturdiness against fire. In fire-resisting window construction something can be done by substituting metal sash and casings for wood and in using a wire-reinforced glass instead of plain glass. This construction has its limit of resistance at the melting point of glass.

Truly, the outlook is not a bright one for the architect who is looking for some means to make his window openings proof against the entrance of fire without any sacrifice of other desirable properties. This, however, does not excuse him from the duty of doing the best he can with the means at hand. In the majority of cases these means are efficient, and a case in hand is the Granite Building, at Rochester, whose comparative safety could probably have been secured by the methods that have already been specified. The hazard to which the Granite Building was exposed is the normal exposure hazard of the tall building in our modern cities. It is only once in a generation that a building is called upon to endure the attack of conflagration, but it may have to resist exposure fire from a neighboring structure at any time. Protection against the normal exposure hazard is practicable, but it cannot be secured without some sacrifice of other things. Reduction in the number of window openings, shutters, wire glass, metal sash and frames, etc., are each objectionable to a greater or less degree, but they must be endured if greater safety from the penetration of fire is expected.

The preceding remarks have been based on the assumption that protection against exposure fires consists solely in preventing at all points the entrance of fire to a building from the outside. This is seldom possible; in a hundred or more openings one or two are likely to give way wholly or in part. To meet this contingency a second line of defense is necessary, and this is had in an interior construction, which will confine the damage to a single compartment of the structure. The breaching of a ship's hull with the result that a single watertight compartment alone is flooded is an exact analogue. The interior construction of buildings so as best to prevent the spread of fire is too broad a subject to be elucidated here and it will be reserved for future discussion, but it is essential to note that it is a part of the problem of protection against exposure fires.

To summarize briefly the contentions made in this discussion, the experience of the Baltimore and Rochester fires fully justify the existence of the modern tall fireproof building; the duty before architects and owners is, therefore, to improve the resistance of these structures to fire; the greatest need for improvement is in the direction of greater resistance against attack from the outside; shutters and protective window construction coupled with a fireproof interior construction will resist the attack of exposure fires of the ordinary magnitude.

LETTERS TO THE EDITOR.

Reasons Favoring the Use of Studs in Marking Sewer Branches.

Sir: As a matter of justice to the majority of overworked, underpaid and unappreciated city engineers in the smaller towns and cities some reply is necessary to the last letter printed in the discussion about the use of studs for marking sewer branches.

The writer has used them in his own practice and thinks it infinitely better in the greater number of cases to put them in than to try to persuade the average councilman to pay better salaries to assistants.

There is no doubt that engineers generally are underpaid, but that is aside from the question of marking sewer branches with studs. The writer knows, and hundreds of engineers in their own experience know, towns where the records are lost every year or two by reason of the carelessness of the elected city clerks and officials whose duty it is to look after them. City engineers change often, for the office seldom pays enough for a man to fool long with it. Sometimes the city will not have a regular engineer after the sewer system is built. If studs are placed at each wye, and it is pretty generally known that the wyes are about so many feet apart, it will not be necessary to hunt up lost records when a house connection is made.

The drainlayer will simply measure roughly from a street corner or a manhole to about where he thinks a branch may be found and then dig a few inches until he discovers the end of a piece of 2 × 4, which appears to be vertical or nearly so. By following it down he will find the branch. If the bottom is at the branch the top can be two feet out of the way. The drainlayer has only to follow it down.

The writer has seen work done by engineers, working for $65 per month, who were rushed to look after their work. The only assistants they could possibly secure were relatives of councilmen or fellows with a political pull, and the city would not pay them more than $1.50 for ten hours work—less than the laborers received.

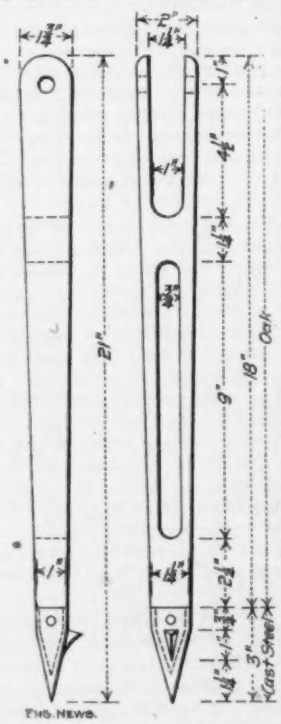
Considering that records may not be carefully preserved and that the councilmen can not be persuaded to pay enough to get the better class of assistants urged by your correspondent, it seems a common sense idea to mark the sewer branches in a manner which will require a minimum of records and triumph over the difficulties of tackling the political assistant problem. In fact, it looks like good engineering. Yours truly,

Ernest McCullough.

3658 Cabanne Ave., St. Louis, Mo., Mar. 5, 1904.

The Advantage of a Short Tripod.

Sir: I herewith submit sketch of a leg of a 21-in. fixed tripod, the value of which, to an engineer on construction, cannot be overestimated. With it I find no difficulty in setting up on a 12-in. wall or foundation and many times by being able to do so save myself the time and unnecessary work of offsetting to get around it, and then there are many times when this short tripod is a great help to me in solving the problems and difficulties which will come to an engineer on this class of work.



Detail of Leg of 21-in. Fixed Tripod.

I do not here wish to go into detail as to the many problems which will present themselves for solution to the engineer laying out the work, but I have found that by using a short tripod in connection with one of standard length that difficulties have been materially lessened.

Some will say that it would be impossible to do accurate work with an instrument set up on a 12-in. wall as the instrument could not be properly manipulated; but that is a mistake, for accurate work has been done and is being done under such conditions, and, also, it is necessary that an engineer be to some extent an athlete to be a successful man in the field.

Yours truly,

W. H. Hendricks.

827 Linden St., Allentown, Pa., Feb. 18, 1904.

Methods of Obtaining Mean Velocity of a Cross-Section in Gaging Streams.

Sir: Your columns being open to discussion of questions of interest, I would like to present the following, inviting a discussion of those interested in the subject:

In measuring the discharge of streams of any character, whether rivers, canals or flumes, when using a current meter, I believe it is the common practice to first make the measurements of depth at regular intervals across the stream, then dividing the width of the stream into sections of greater or less width according to the size and character, taking the velocity, by means of one of the recognized methods, either the point, the six-tenths or the integrating method; and taking the velocity for each section as being the mean of the velocities ascertained with the meter at each side of this section. In the case of the two end or shore sections, the velocity at the edge is taken to be zero, and the mean velocity is therefore taken to be the mean of the observed velocity at the first station and zero.

This practice I believe to be wrong, though a cost of my work is to be compared with measurements taken by others who use that method I, perforce, must also do so. If this end section is a triangle with bank slopes of 45° and smooth sides, this method would be proper. When, however, the slopes are either very flat or are nearing the perpendicular, and particularly where the sides are actually perpendicular, as in the case of a rectangular flume, this will certainly not give correct results.

Some time since the late Benj. F. La Rue, C. E., then Professor of Civil Engineering of the International Correspondence Schools, in connection with this subject, wrote a private letter to one of his students, which the writer has lately had the pleasure of seeing, as follows:

It is somewhat erroneous to consider the mean velocity for the first section and for the last section to be one-half the velocity at the first and last stations. This is virtually assuming the velocity at the edge of the stream to be zero, which is far from being the case. While no absolute rule can be given for this, I would be inclined to take the difference between the velocity of the water at the edge and its velocity at the first station to be, say, from about 1¼ to 1½ times the difference between the velocities at the first and second stations. I think this would represent the actual conditions with reasonable accuracy. It might be well to make the ratio 1½ in a stream having a reasonably irregular edge, and 1¼ or less in a channel having straight or nearly perpendicular sides.

This rule followed out would make a material difference in the results obtained from that commonly used.

Will hydrographers give their methods where differing from either of the above, or their opinions as to the best method to pursue to secure correct results?

Very respectfully,

H. F. Robinson, Irrigation Engineer.

P. O. Box 396, Phoenix, Ariz., Feb. 29, 1904.

The Permanent Expansion of Cast Iron by Heat a Danger in Building Construction.

Sir: I have just read in the "Iron Trade Review" a reprint of the article in your issue of Feb. 18 on the Baltimore fire, in which you say that "one of the most surprising effects of the fire was the noticeable extent to which cast iron had suffered permanent bends." You do not mention the increase in cubic dimensions, which is a very important matter in connection with the use of cast iron in modern skyscraper buildings.

While absent from home last month I received a letter from the Trust Officer of the Land Title & Trust Co., of this city, owning and occupying two of the largest buildings of this kind in Philadelphia, which read as follows:

The chief engineer of the Land Title Buildings, who went to Baltimore to inspect the effect of the conflagration upon the Continental Trust Co.'s 16-story building, tells me that while the entire contents of that building were "roasted" and consumed, the steel framework is apparently plumb and intact. He also says that the cast-iron framework of the doors (which was set in granite) has expanded and bent to a considerable extent, and has not again contracted; this permanent expansion is very noticeable.

From other engineers I have some reason to believe that if the framework of the doors had been of light steel and the doors of non-combustible material, the valuable contents of this building might been saved from complete destruction.

The tables giving approximate expansion of steel and cast iron by heat show comparatively little difference; the "buckling" of cast iron is due to the constantly increasing dimensions of this metal, up to at least 40% in volume, when subjected to high temperature, but far below the melting or even softening point of the metal.

The photographic illustrations accompanying my paper on "Recent Investigations in Cast Iron," in the Journal of the Franklin Institute for February, 1904, and in a similar paper read very recently efore the American Institute of Mining Engineers, the result of many tests made with these and other metals during several years, show facts, which, if known generally to architects and constructing engineers, would, I think, have prevented them from using cast iron for the framework of doors and windows in modern fireproof tall steel buildings.

I regard the surprising effects, noted by you, of the fire on cast iron as a valuable and timely practical illustration of the importance of a correct understanding of the difference in behavior of cast iron and steel when subjected to prolonged heating. The cast-iron bars which I caused to increase in volume or cubic dimensions over 40% were in no instance heated to a degree approaching softening of the metal. The bars of a "protective grating" increased several inches in length, but shows no tendency to "sag,"

though the grating was laid horizontally on the floor of a core oven, showing that these bars had not been heated to anything near the melting point.

If steel behaved in the same manner as cast iron does when heated, I am quite convinced that the Continental Trust Building in Baltimore instead of being "plumb" to-day would have toppled over during the fire, not from temporary expansion, or from softening of the metal, but from actual growth of the metal in cubic dimensions. The lesson taught by the Baltimore fire, if not by my previous studies, is, do not combine cast iron and steel in such buildings in the future. I am, yours very truly,

Alex. E. Outerbridge, Jr.

1000 Hamilton St., Philadelphia, Pa., March 7, 1904.

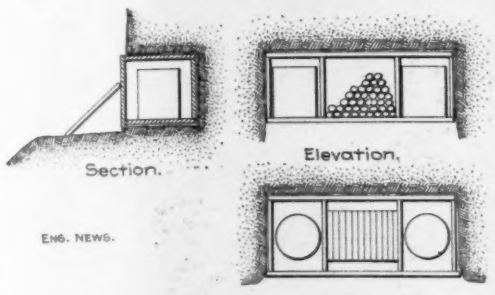
A Hot Water Thaw-Box for Dynamite.

Sir: Some four or five explosions of from one-half to two boxes of giant powder have occurred upon work under my supervision within a period of about five years, all, very fortunately, without fatal results, though in at least two instances a very slight change in time or circumstances might have resulted in a very distressing accident.

I read with interest Mr. Hulse's letter upon the thawing of giant powder under date of Feb. 2, 1904, with your comment thereon, appearing on page 130 in Engineering News, of Feb. 11, 1904.

During the past winter I noticed that Mr. John McCrimmon, while working upon a cut a short distance east of the Mullan Tunnel on the main line of the Northern Pacific Railroad, in this State, was using an arrangement for thawing dynamite that apparently gave entire satisfaction, and I enclose herewith sketches thereof.

Mr. McCrimmon found a pit in the ground which he utilized for the purpose, but I show it as cut into a bank, although the box might be used on level ground and covered with earth to a depth that will secure an even temperature. The box is constructed of such materials as are generally available; the cans used were discarded powder cans, but coal oil cans answer quite as well, and almost any discarded vessel will answer.



A Hot Water Thaw-Box for Dynamite.

Twice a day, or oftener if necessary, the water is turned out and the cans are filled with boiling water; the powder is piled betwen the cans as shown, or the chamber may be made large enough to receive one or more unbroken boxes of powder. Where the ground will stand, the exterior box shown is not required unless it be to assist in making the door with which the front is closed, air tight. An old blanket or tarpaulin will often serve this purpose well.

The idea is not altogether new, perhaps, as I have seen many arrangements very similar to this, but none I think which is more easily made, of material usually available and which is, so far as I can discover, without an element of danger that is not inherent within the powder.

A small air tight pit of this construction, will with little attention, keep a constant supply of powder in perfect condition through as severe weather as men are likely to wish to work. Respectfully yours,

Joseph H. Harper.

16 West Quartz St., Butte, Mont., Feb. 23, 1904.

Why Does Earth Shrink?

Sir: Through your columns kindly inform me as to what manner of tests were made by Elwood Morris, in 1840, in reference to shrinkage of earth from cut to embankment, as referred to in your article in Construction News, Feb. 25. I desire this information to get a clear idea as to whether the earth shrinks or is lost by subsidence, wash or sloughing beyond the confines of the theoretically staked out embankment. The latter seems the most probable, for it is difficult to conceive that moderately well-packed earth in place can shrink 10% unless data are given to substantiate such a state of affairs. An answer to this matter in your columns will be appreciated, as I have seen frequent reference to this shrinkage by high engineering authorities, but as to tests I have seen nothing. Yours truly,

Wm. D. Faucette, Jun. Am. Soc. C. E.

Assistant Engineer's Office, S. A. L. Ry., Savannah, Ga., March 5, 1904.

(Why earth in situ is ordinarily less compact than an embankment made with carts and scrapers has puzzled many engineers. Earth, whether deposited by water or by glacial action, may be quite dense at the time of its deposition; but during the centuries that follow there are many forces at work tending to increase the percentage of voids.

Water, slightly charged with carbonic acid gas, dissolves limestone with comparative rapidity; hence the voids in limey earth are soon increased. Feldspar fragments disintegrate chemically, and lose certain salts by solution in water. Even quartz itself is slightly soluble, as is evident from an examination of plants whose ashes contain silica. Thus, by solution the voids are slowly increased in all soils.

The roots of plants not only drink up these earthy solutions, but upon their decay they furnish vegetable acids which further accelerate solution. It is, in fact, well known that loam is exceedingly porous.

Earth worms, insects and burrowing animals have all been agents also in loosening the surface soils. Frost is an agent tending to make the surface layers of earth more porous by crowding the particles apart into new arrangements.

The steady movement of ground waters may, in coarse gravels, carry away some of the exceedingly fine fragments in suspension.

Wind is an active agent in loosening sand, as those who have seen "sand dunes" in motion will readily understand.

Clay shrinks as it loses water and swells again as it takes up water. Hence a dense mixture of clay and sand may readily become more porous by means of this frequent variation in the volume of the clay.

Finally, any jarring, pounding or rolling action will reduce the volume of comparatively dense earth by forcing the fragments into new positions of greater stability—which is equivalent to saying that the voids are reduced. Hence it is not strange that an embankment subjected to the pounding of hoofs and wheels is more dense than the natural earth.

The historic experiments of Morris showed an actual shrinkage of embankment during construction, so that the finished fill measured 9 to 13% less than the cut from which it was taken. This shrinkage was largely due to the pounding of hoofs and wheels, for the embankments were made with scrapers and carts, and it was not due to any sloughing off or "squatting" of the embankment. A series of controversial letters on the subject of earth shrinkage appeared in our issues of Nov. 22, Dec. 13, Dec. 20, 1900, and Jan. 3 and 10, 1901. The data given in those letters, as well as the data of Morris and other experimenters, may also be found in a chapter on "Earth Shrinkage" in Gillette's "Earthwork and Its Cost."—Ed.).

The Permissible Working Unit Shear for Concrete-Steel Beams.

Sir: I beg to call attention to a working stress for concrete which custom seems to be setting at an unjustifiably high figure. The stress in question is the permissible unit-shear. The value assigned to it in the New York city building regulations (Engineering News of Oct. 8, 1903) is 50 lbs. per sq. in. Two correspondents in your issue of Feb. 18 (Messrs. A. L. Johnson and Julius Kahn) give countenance to the same value, Mr. Kahn suggesting even 60 lbs. This value I understand to be intended as the quantity permissible in a beam without transverse reinforcement, as the quotient obtained by dividing the vertical shear by the cross-section of the beam. If this view is correct, the values stated imply a working factor of safety of two or less, as shown by the tests of concrete beams reported by Professor Lanza in the Transactions of the Am. Soc. C. E. (Vol. L, p. 486) and quoted in part by Mr. Kahn in the issue of Engineering News just cited. Omitting from consideration such beams as failed otherwise than by the diagonal cracking spoken of as "shearing," and also such as had vertical or diagonal reinforcement (i. e., omitting beams 1-4, 12, 13, 14, 19, 21, 26, 27 of that series), the average shear at which the 15 beams failed was 102 lbs. per sq. in., with a minimum of 73 lbs. for beam 7 and a maximum of 127 lbs. for beam 11. This was a fair quality of rock concrete, four to seven weeks old. These figures were obtained by halving the center load plus the weight of the beam and dividing by 96, the cross-section of the 8 × 12 beams. For example, for beam 11 the ultimate unit shear was

$$\frac{1,294 + 23,105}{2 \times 96} = \frac{24,399}{192} = 127 \text{ lbs.}$$

Of a series of beams recently tested by the writer, three which failed in a similar manner, and which are otherwise fairly to be considered in this connection, showed an ultimate unit shear of 111, 111, 100 lbs. per sq. in., respectively. This concrete was of 1 part Portland cement to 2½ parts of highly silicious crusher dust, cast at a consistency of cream in sand molds. The beams were six weeks old when broken and were very dense and homogeneous. The aggregate was such as would pass a No. 8 seive, and the concrete must be looked upon as rich.

Further, it may be stated that Christophè puts the limit for vertical shear which should not be overstepped without transverse steel reinforcement at from 14 to 30 lbs. per sq. in. (Le Béton Armé, 2d ed., p. 635), about such a value as would be indicated by the tests cited.

It may be, as Mr. Schaub suggests in the Engineering News of Feb. 18, that this kind of failure is due to the slipping of the longitudinal reinforcement and can be obviated by effectively anchoring the ends of the rods which form this reinforcement. If this can be generally substantiated, such anchorage ought always to be used or, at least, decidedly less than 50 or 60 lbs. per sq. in. should be taken as the allowable unit shear in a concrete beam without transverse reinforcement. The experiments cited would indicate that the upper limit of 30 lbs. as recommended by Christophè is quite high enough. Mr. Kahn's beam, shown in his Fig. 11, seems to have failed with the ultimate shear at 187 lbs., but this may well be an abnormally high value and even this would hardly justify 50 or 60 as safe.

In the present state of our understanding of the action of concrete-steel girders, it behooves us to keep the permissible unit stresses at a conservative or even ultra-conservative figure.

As to the respective merits of diagonal or vertical reinforcement, the author believes that the vertical can be made effective, just as vertical rods are effective for taking up the vertical shear in a Howe truss—a truss more properly taken as an analogue to a concrete-steel girder than the Pratt type. In the girder the diagonal concrete struts thus implied are amply able to take care of the compressive stresses and the steel is minimized in amount by putting it in a vertical plane in the girder just as in the Howe truss. Moreover, the vertical position permits the use of any of the ordinary rods "deformed" or plain, without resource to any patented arrangement for uniting diagonal reinforcement with the longitudinal. Furthermore, vertical reinforcement makes the minimum interference with placing the concrete. The writer hardly likes to contemplate trying to stow concrete properly for a girder 16 by 45 or 50 ins. deep with 45° reinforcing frames or wings of any kind.

To refer once more to Professor Lanza's experiments above cited, it may be noted that the one beam of the series, beam 13, which carried a shearing stress strikingly higher than any of the rest was one with vertical reinforcement. Doubtless this value would have been materially heightened if it had been the purpose to pay careful attention to the design and placing of these stirrups. The writer is about to publish elsewhere details of a couple of tests which point more strikingly still to the effectiveness of vertical reinforcement. Even the diagonally reinforced beams in Professor Lanza's series showed a slight but surprising superiority over the beams without transverse reinforcement, considering that the stirrups were not united with the longitudinal steel, as diagonal reinforcement of course should always be.

Be all this as it may, the writer hopes Mr. Shaub's contention may be established. Transverse reinforcement is too uncertain as to its correct design, and too troublesome in actual construction, to make one wish to advocate its use for one moment after a way for obviating it has been established. As between diagonal and vertical reinforcement, the arguments are by no means all on the side of the diagonal. Very truly yours,

L. J. Johnson, Assoc. M. Am. Soc. C. E.

Harvard University, Cambridge, Mass., Feb. 27, 1904.

The Government Cement-Making Plant at the Tonto Dam, Arizona.

Sir: Referring to the article in your issue of Feb. 25 on the interesting questions raised by the government building a cement-making plant at Tonto Basin, Salt River Valley Arizona, the writer would call your attention to the following:

It is understood that the construction of this factory was authorized by the Secretary of the Interior about a year ago on the assumption that the government could make a high grade of Portland cement at the dam site for $2 per bbl., while cement brought from other points of manufacture could not be delivered there under $9 per bbl.

One objection the writer, as a cement manufacturer, has to the government building this factory is that its construction was authorized on the *assumption* that cement brought in from outside would cost $9 per bbl. instead of first asking for formal bids and finding out what it would cost. No formal bids were asked for this cement until after protests were made by the cement manufacturers. The bids received on Feb. 20 show that cement can be bought for $4.81 per bbl., or $4.52 per bbl.

if the government did not retain 20% of each payment until completion of the work.

The bond required was unusually large, amounting to between $250,000 and $400,000. This large bond and the fact that 20% of the payments were to be held back some 18 months to two years would not encourage low bidding. Yet, notwithstanding these discouraging conditions, it will be noted that cement can be bought for about one-half of what the government estimated.

As to making a good quality of Portland cement at the dam site for $2, that is another estimate which the writer does not doubt will prove nearer correct than the first estimate, as the investigation of material at the dam site was under the supervision of Mr. Ed. Duryee, one of the best posted cement men in the Southwest. However, if the government required a bond from the engineers in charge of making the cement at the dam site of only 33% of the amount asked of private manufacturers as a guarantee that they could produce the desired amount of first-grade Portland cement in the required time at $2 per bbl., it might be hard to find engineers to go on with the work.

There is another point that some of the papers have overlooked, and that is that the cost of the cement mill will be about $1 per bbl. of cement manufactured at the dam site (and the mill is being located where it could not afterward be operated for commercial purposes), so that the total cost of the cement manufactured would be about $3 per bbl., or $1.81 per bbl. less than the lowest bid. But here comes another point which almost wipes out this difference: the cement from the factories bidding will be shipped over land-grant railroads; the government is entitled to a rebate of 50% of the rate, so that when the rebate is credited to the price of cement, it makes the cement from private parties almost as low as the government estimate for making it on the ground.

The cement manufacturers protest against the government going into the manufacturing industry in competition with private individuals, and you report that the Secretary of the Interior refused to consider the matter from this point of view, as the government's duty, as trustee for the future water users (landholders), was to see that the work was done in the best and most economical manner. This view might be tenable if these landholders had raised the money for the dam and the government only had charge of the construction. In this case, however, the United States money and the United States' credit is being used to build this work. The benefit of the work will be received exclusively by the owners of 200,000 acres of land near Phoenix, Arizona, all of which is patented land and valued at the present time from $25 to $300 per acre.

It is well to bear in mind that the water stored by this dam cannot be used to irrigate any land opened for settlement under the Homestead Law or the Desert Land Act, yet the writer does not believe anybody who has traveled over the arid Southwest would object to the government financiering this or any other private irrigation schemes too large for local capital to undertake, provided the money was to be spent under established government precedents. On the other hand, if the government credit is to be used in establishing precedents for government factories to compete with private individuals, the writer thinks the general business community should make such representations to Congress as would prevent such procedure.

It has been intimated that if the cement were bought from private parties that the railroad rebate of 50% of the freight as mentioned above would go into the U. S. Treasury and not be credited to the building of the dam. Referring to the statement that the Secretary of the Interior says it would be a fraud on the future landholders to pay more for cement than it would cost the government to make it, the writer would say that the landholders are here now and many of them farming the land. They have given the government a first mortgage on the land to cover the cost of developing this additional water needed by them to increase their hay crops from 3 to 8 tons per acre.

If it is a fraud to let private citizens who have helped develop the country by building cement mills make something out of the manufacture of the cement to be used in the construction of millions of dollars worth of work being planned under the Newlands-Hansbrough Act, would it not be an equal fraud for the U. S. Treasury to profit by it? If the Treasury did not profit by it, the cement from private parties after being credited with this freight rebate would be so near the government estimate for making it on the ground that it would not warrant a government mill.

The writer deprecates the continued insinuation in your article that the government was confronted with the fact that free competition between cement manufacturers would be doubtful. Being personally acquainted with the engineers in charge of this work, he does not think the fear of a combination among cement bidders was taken into serious consideration. Their only thought was to build this work economically, and at the time of recommending the mill to be built they thought they could save about $6 per bbl., or a total of $1,250,000 by making the cement on the ground, and that this saving was sufficient to warrant the use of an untried material in this great structure—"the largest masonry dam ever built." The larger question whether the government was justified in competing with private industry was left to the authorities at Washington.

Again referring to your statement that the engineers had to face a threatened combination of cement producers, nobody should know better than you (who report all cement lettings) that nobody has had to face such a combination in the past. If you have any information about such a future combination, let us hear about it through your columns.

This silly talk of a cement combination trying to hold the government by the throat and exacting $9 per bbl. for cement worth only $2 per bbl. is largely due to dispatches sent all over the country by a certain well-known newspaper correspondent at Washington, who did not care so much for the truth as to have a sensational article to send out.

These dispatches have been widely printed and indignant editorials have been published on this subject in many of the Western papers, so at the present time Western farmers believe that the cement output is controlled and marketed similarly to the kerosene oil output of the country.

If there ever was an article that had sustained a cut-throat competition it is cement, which is now selling below the cost of production in many factories. All this wild talk about a "cement trust" is due to the fact that the American cement manufacturers asked the Secretary of the Interior why it was they were not allowed to bid on the cement wanted for the $10,000,000 to $20,000,000 worth of irrigation work planned for construction in the West. Why it was that money appropriated under the Newlands-Hansbrough Act was being used to erect cement factories, which act did not appear to many to authorize such a procedure.

You refer to the possibility of a government armor-plate factory, owing to the apparent lack of competition in that commodity, yet with the manufacture of this material in the hands of only two parties, Congress has been very reluctant to authorize the government making its own armor plate. It is hardly to be supposed the Navy Department would undertake to use government money for this purpose without authority from Congress. So there is no comparison between the proposed government armor-plate factory and the government cement-making plant now being built in the Salt River Valley of Arizona, as Congress apparently never authorized the construction of the latter.

I trust you will see your way clear to publish this letter and also to investigate the threatened combination in cement prices and set this matter right in your editorial columns. Respectfully,

Wm. G. Hartranft, Assoc. Am. Soc. C. E.

Phoenix, Ariz., March 4, 1904.

(Our correspondent appears to have somewhat misunderstood the position taken in our editorial.

FIG. 1. BLUESTONE FRONT OF BALTIMORE & OHIO OFFICE BUILDING DAMAGED BY FIRE.

FIG. 2. MARBLE FRONT OF RIALTO BUILDING DAMAGED BY FIRE.

It was merely that the Government engineers should be as free to carry out their work in the most economical manner as they would be if the work were being done by a private corporation. If it is more economical, actually, to make the cement on the spot than bring it from the far distant mills, then they should be free to choose the more economical plan. If we were to take the other alternative and establish the principle that the government should not manufacture anything which it might purchase instead, the owners of stone quarries might protest against the Government quarrying local stone for use in the Tonto dam.

As for the matter of combination among cement producers, we said nothing concerning any general combination, but merely showed that the geographical conditions gave one producer a great advantage over any other, and practically restricted the effective competition to three or four bidders at most. An engineer who did not appreciate the importance of this fact would show a very poor grasp of the commercial side of engineering.

Whether the land to be benefited by the stored water is now in the hands of private owners and settled or not, would seem to have very little to do with the matter. Either present or future owners are entitled to have the work to be done by the Government and charged against their property, performed in the most efficient and economical manner.

Finally, the cement manufacturers are likely to receive a very large slice of the millions of dollars to be expended under the Newlands-Hansbrough

Acts and no one, so far as we are aware, has proposed any other course than the purchase of cement from the manufacturers for all this work, except where it may be done under such unusual conditions as exist at the Tonto dam.—Ed.).

SOME EXAMPLES OF EXTERIOR WALL DAMAGE IN THE BALTIMORE FIRE.

One of the effects of the Baltimore conflagration which has been most frequently commented on by all who have examined the burned buildings, is the wholesale damage done to stone facades of almost every description. Few, if any, of the buildings having exterior walls of stone or with stone facing or finish, fail to show evidences of this destruction. Some kinds of stone withstood the attack better than others, but generally speaking, all stone work suffered injury. The character and extent of the damage done are excellently indicated by the accompanying engravings from photographs taken after the fire.

Fig. 1 shows the appearance of the first story facade of the Baltimore and Ohio office building. This masonry was of bluestone and was subjected to the flame from a 6-in. gas pipe for a period of about 30 minutes. Fig. 2 is a view of the Rialto Building. The pillars and columns were of marble. Fig. 3 is a view of the sandstone facade of the Maryland Trust Building. Fig. 4 shows the damage to the granite lintel and side pillars at one of the front windows of the Continental Trust Building.

Another interesting feature of the Baltimore fire, which, however, has been rather neglected in the accounts so far published, is the record made by fireproof shutters. The accompanying illustrations show a number of buildings whose windows were protected by shutters and also the appearance of these shutters after the fire. Fig. 5 shows the rear and wall of the Maryland Trust Building whose windows were protected by double-flap hinged shutters of the underwriters' type, that is, of wood sheathed with sheet-iron. A similar view of the rear of the Herald Building is shown by Fig. 6, and Fig. 7 shows in more detail four of the worst damaged windows in this building. Fig. 8 shows the front of a four-story brick building with both doors and windows provided with shutters.

The views, Figs. 5 to 8, inclusive, show clearly the condition of the window protection and need not be elaborated from this point of view. It is necessary, however, in considering the evidences of shutter destruction to bear in mind that these shutters were all attacked on both sides. Fire entered the buildings from the unprotected front windows so that the rear window shutters had to endure a fierce fire on both sides. This is a test of endurance for which they were never intended.

COMMITTEE REPORTS OF THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION.

A number of reports have been prepared for the annual meeting of the association in Chicago, March 15 to 17, and abstracts of some of these are given below, in accordance with our usual practice.

Ballasting.

CRUSHED ROCK.—In general, crushed rock comes nearer to filling the requirements of an ideal ballast than any other material. It is pliable and elastic to a considerable extent, though not so much so as some other ballast. It will not entirely prevent growth of weeds, but is much more effective in this regard when clean than when the spaces are filled with dirt. This may occur by the fine, soft material of the roadbed working up through the rock or by the fall of cinders and dirt from trains from above. Complete filling of the spaces in crushed rock almost entirely destroys its usefulness, and it then becomes necessary to put new ballast on top of the old or to clean it. It is cheaper to put in new ballast than to take out and clean the old, but an additional raise may be objectionable, particularly on the approach to a large bridge which cannot be raised without great expense.

In crushing rock, many fine particles are made and usually screened out. The screenings must be disposed of in some manner, and the question of their suitability for ballast arises. They can be used in ballasting side tracks, for leveling up between tracks in yards and for making platforms at unimportant stations. Used as ballast, they form a firm bed around the tie, but do not drain well, and consequently churn when wet. They are unsuitable for main line work.

GRAVEL.—This cannot be procured ordinarily in a form which will satisfy definite specifications, therefore, it is not worth while to draw them. The users of gravel ballast can only choose from the available deposits. The most desirable gravel ballast consists of a clean uncementing gravel, varying in size from coarse sand to 2 ins. diameter. The practice of surfacing new track with earth and loam is not economical when gravel is available with a haul of not over 100 miles. The cost of renewing ties in gravel ballast varies with the frequency of train interruptions, from 6 to 10 cts. per tie in loose gravel, and from 10 to 20 cts. in cementing gravel.

BURNT CLAY.—Its use has met with varying results, largely due to the quality of the material burned and the manner of burning. When the clay contains little sand and a sufficient quantity of fluxing material to produce a semi-vitreous mass, a very good quality of ballast will be produced, giving good results on roads with comparatively light traffic, and is to be commended because of the ease with which it can be worked. On roads with heavy traffic and heavy rolling stock burnt clay ballast has not given good satisfaction because of being too soft to stand the load and the disintegrating effect of the weather.

SLAG.—Slag which is most uniform in size and heaviest in weight is most valuable for ballast purposes. These qualities depend largely on how it is made. Sometimes the slag is drawn from the furnace and run directly into long depressions or shallow ditches. This gives a number of slabs of half round section, 10 or 12 ins. wide, which must be broken up with hammers or crushers before it is used. The large pieces may be used at the foot of the slope of the ballast to hold the smaller pieces in place, but are a decided disadvantage when they get under the tie. They must then be broken up with a sledge before track can be surfaced. The product is much more satisfactory where the slag is carried in a hot pot from the furnace and poured upon a dump.

When the slag contains an excess of free lime or has been formed in thick layers, a large portion will be found to be spongy. This is likely to become pulverized under the track, cementing together, becoming difficult to work and churning in wet weather. The vitreous or glassy slag often breaks into pieces nearly cubical in form and of remarkable uniformity in size, the pieces being about 1-in. in each dimension.

Slag ballast track usually requires a lift of 2 or 3 ins. and to be surfaced out of face at intervals of 2 to 6 years, depending on the quality of the material and the traffic it sustains. Slag is cheaper in first cost than broken stone, but the cost of maintenance is somewhat higher and the effect upon the ties is said to be detrimental because of the chemical action of the slag. The cost of renewing ties in slag ballast varies from 9 to 15 cts., depending upon conditions.

It is the conclusion of the committee, in the light of arguments presented, that stone ballast made from hard, durable stone, broken in sizes from ¾ to 1½ ins., having a depth under tie of 12 ins., resting on a firm, well-drained roadbed, will best meet the requirements of roads with heavy traffic, large engines and fast service.

J. V. Hanna, C. A. Paquette, W. W. Colpitts, F. T.

FIG. 3. SANDSTONE FRONT OF MARYLAND TRUST BUILDING DAMAGED BY FIRE.

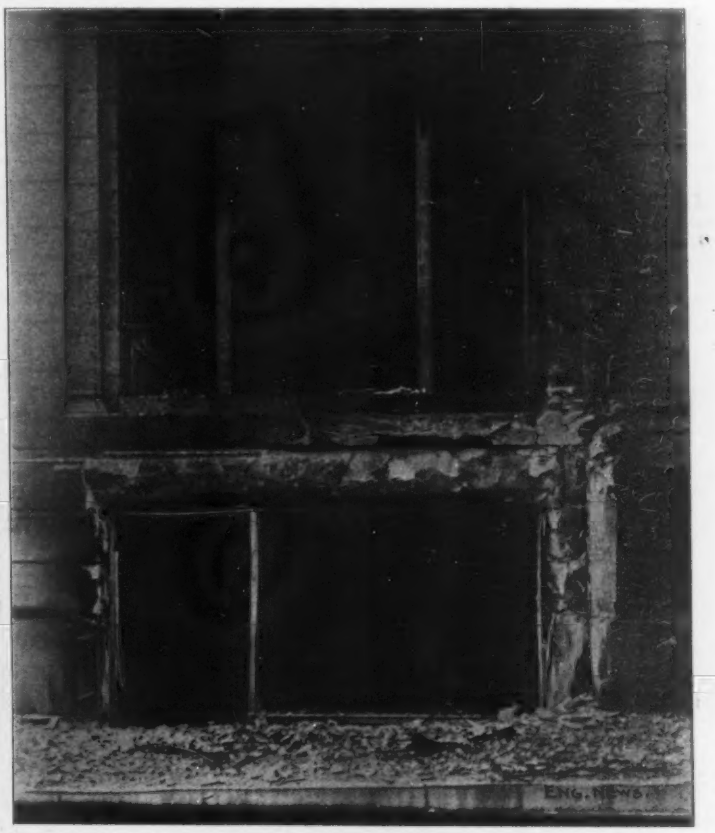


FIG. 4. GRANITE LINTELS AND PIERS OF CONTINENTAL TRUST BUILDING DAMAGED BY FIRE.

Hatch, E. Holbrook, J. O. Osgood, J. G. Sullivan, G. M. Walker, Jr., Committee.

Ties.

The accompanying table gives a correct list of the tie treating plants in the United States:

TIMBER PRESERVING PLANTS IN THE UNITED STATES.

Location.	Year built.	Owner.	Process.	Kind of wood.	No. retorts.	Est. capacity, ties per annum.
Portsmouth, N. H.	....	Otis Allen & Co.	Kyanizing	Spruce	4	150,000
Lowell, Mass.	1848.	Otis Allen & Co.	Kyanizing	Spruce	2	
Las Vegas, N. Mex.	1885.	A., T. & S. F. R. R.	Burnettizing	Pine	3	500,000
Bellemont, Ariz.	1898.	A., T. & S. F. R. R.	Burnettizing	Pine	2	350,000
Chicago, Ill.	1886.	Chi. Tie Pre. Co.	Zinc-tannin	Hemlock	4	500,000
Mt. Vernon, Ill.	1899.	Chi. Tie Pre. Co.	Zinc-tannin	Black oak	1	200,000
Somerville, Tex.	1897.	Texas Tie & L. Co.	Various	Pine, etc.	6	2,500,000
Kalispell, Mont.	1901.	Great Northern Railway.	Zinc-tannin	Pine fir	4	1,200,000
Houston, Tex.	1891.	Southern Pacific Co.	Burnettizing	Pine	5	1,500,000
Oakland, Cal.	1889.	Southern Pacific Co.	Creosoting	Pine, etc.	2	1,000,000
Cal. & Oregon.	1894.	Southern Pacific Co.	Burnettizing	Pine fir.	2	1,000,000
Beaumont, Tex.	1897.	Int. Creo. & Con. Co.	Various	Pine, etc.	1	500,000
Sheridan, Wyo.	1899.	Chic., Bur. & Q. Ry.	Burnettizing	Pine, etc.	2	700,000
Greenville, Tex.	1901.	Mo., Kan. & Tex. R. R.	Zinc-tannin	Pine gum	3	900,000
Alamogordo, N. Mex.	1902.	Alabama Lumber Co.	Zinc-tannin	Pine, etc.	2	600,000
Portable plant.	1902.	Union Pacific Ry.	Burnettizing	Pine, etc.	2	600,000
Portable plant.	1902.	Oregon Short Line	Burnettizing	Pine, etc.	2	600,000
Carbondale, Ill.	1902.	Ayer-Lord Tie Co.	Various	Red oak	7	3,500,000
Grenada, Miss.	1903.	Ayer-Lord Tie Co.	Various	Pine, etc.	2	800,000
Long Island City.	1878.	Eppinger & Russell	Creosoting	Pine, etc.	4	800,000
Perth Amboy, N. J.	1890.	U. S. Wood Pre. Co.	Creo. resin	Pine, etc.	4	1,200,000
Norfolk, Va.	1896.	Norfolk Creo. Co.	Creosoting	Pine, etc.	4	900,000
W. Pascagoula, La.	1876.	L. & N. R. R.	Creosoting	Pine, etc.	2	400,000
New Orleans, La.	1902.	American Creos. Co.	Creosoting	Pine, etc.	2	400,000
Norfolk, Va.	....	At. Creo. & W. P. Wks.	Creosoting	Pine, etc.	3	600,000
Slidell, La.	....	So. Creos. Co.	Creosoting	Pine, etc.	..	.....
Seattle, Wash.	....	Colman Creos. Co.	Creosoting	Pine, etc.	1	300,000
Everett, Wash.	....	Puget Sound T. P. Co.	Creosoting	Pine fir.	2	600,000
Escanaba, Mich.	1903.	C. & N.-W. R. R.	.....	.....	3	900,000
Texarkana, Tex.	1902.	Int. Creo. & Con. Co.	Various	Pine	2	600,000
Texarkana, Tex.	1902.	So. Tie & T. T. Co.	Burnettizing	Pine	1	300,000
New Orleans, La.	....	N. O. Wood Pres Co.	Various	Pine	1	300,000
Portsmouth, Va.	1881.	Wyckoff P. & C. Co.	Creosoting	.....	..	.....

Inquiries have been made of the various treating plants in this country to determine the number of ties treated during the year 1903, in the United States. Several large works were completed during 1903, not getting in operation early enough to turn out their full capacity during that year. The reports received from all but one of the above works say that 11,254,729 ties were treated during 1903. When this is compared with the statement that five years ago there had probably not been 10,000,000 ties treated in this country, including all years, the growth can certainly be considered remarkable and exceedingly encouraging to those interested in the preservation of our forests and of our tie-wood supplies.

During the past year there have been several new processes for the preservation of wood called to the attention of the Committee, among which may be mentioned the so-called "Rüping process," by which it is claimed to be possible to thoroughly impregnate the cell wall of timber without at the same time filling the cell spaces, resulting in a large economy in the amount of creosote used. If the claims made are correct, this process would seem to offer great promise for the treatment of ties, as thereby the cost of creosoting would be reduced to but little more than the present cost of treating with zinc-chloride. In all probability, the amount of creosote so retained in the tie would be sufficient to furnish protection against decay for a number of years.

Another proposed method of treatment is the so-called Ferrell process,* which is a modification of the Boucherie process. The ties are handled individually into small cylinders adapted for one only, and are there subjected to heavy hydraulic pressure applied at one end of the tie, to force the preservative solution longitudinally through it. The chemicals proposed for use are sulphate of [illegible] and sulphate of alumina. This process naturally divides itself into two parts, one the method of injection, the other the chemicals to be used. It is claimed that by this method of injection followed, the cost of plant and cost of treatment are very materially reduced as compared with works adapted to treat by the ordinary methods, and that the distribution of the preservative is much more uniform throughout the stick than is secured by the usual methods. The Committee has no evidence to substantiate either claim.

E. B. Cushing, Chairman; W. W. Curtis, W. Archer, Robert Bell, E. Ford, R. R. Hammond, E. E. Hart, W. W. Hayden, P. A. McCarthy, J. C. Nelson, S. M. Rose, Committee.

APPENDIX TO REPORT ON TIES: (REPORT ON TEXAS TRACK EXPERIMENTS. BY HERMANN VON SCHRENCK).

In February, 1902, an experimental section of track was laid on the Beaumont Division of the Gulf, Colorado & Santa Fe. Ry. In this track both treated and untreated timbers of various kinds were laid to test the comparative lasting powers of timbers treated with various kinds of treatment. These ties have now been in position about two years, and while it is as yet rather early to derive any definite conclusions from this test, an inspection made during December, showed the following general results:

(1) All of the untreated timbers show more or less signs of decay. Tamarack, loblolly pine and beech have so far shown themselves as the least resistant of all the timbers. In the case of the untreated tamarack, out of 40 ties, 37 had fungi growing on the ends of the ties, indicating that they were beginning to decay. The various species of oak showed the highest resistance in the untreated state.

(2) Referring to the treated timbers, the most striking results so far evident refer to the bad results with oak timbers which were overheated in the treatment with creosote. These timbers were for a brief period of time exposed to an extreme heat. A large percentage of the ties so treated have during the last year or so broken in the middle or underneath the railbearing, so as to endanger the safety of the track, and they had to be removed. Great stress should be laid upon the results in this particular instance, which should serve as a warning to avoid excessive heating, whether the same be dry or moist heat.

*Engineering News, Feb. 11, 1904.

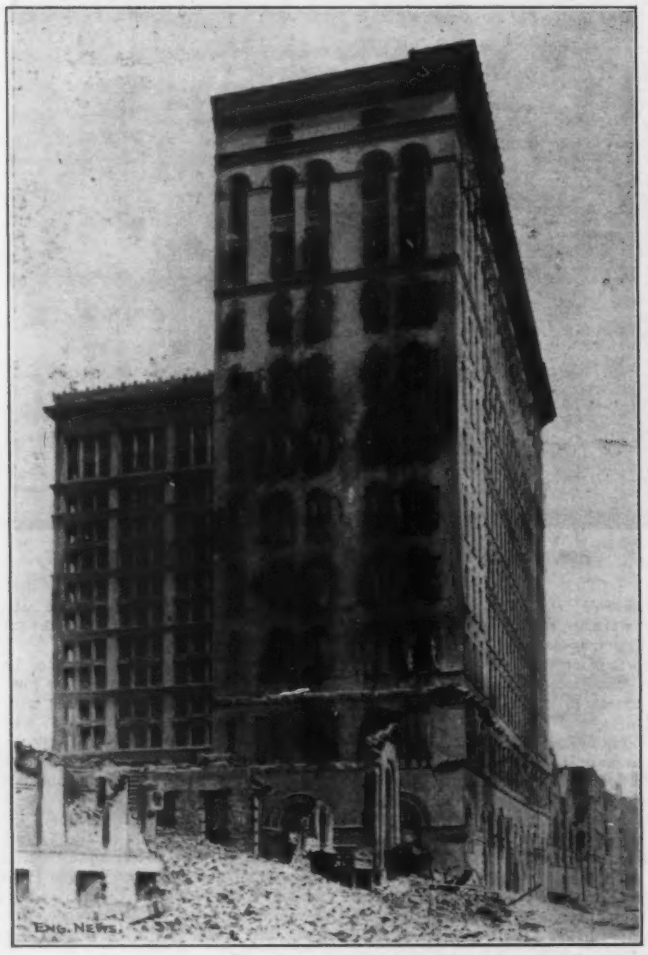


FIG. 5. REAR OF MARYLAND TRUST BUILDING, SHOWING FIREPROOF SHUTTERS.

FIG. 6. REAR OF HERALD BUILDING SHOWING FIREPOOF SHUTTERS.

(5) The ties treated with the zinc-chloride process have so far shown no signs of decay, and there is little evidence of any wear under the rail. The same is true of the ties treated by the zinc-creosote, two-injection process.

(4) Ties treated with spirittine are in every case sound.

(5) Summing up the results which are so far evident, one can say that every treatment has so far protected the timbers against decay, and, in view of the fact that all of the untreated timbers are decaying, this stretch of track

FIG. 7. DETAIL VIEW OF SHUTTER DAMAGE ON HERALD BUILDING.

is already forming an object lesson of great interest as to the value of treated timbers. A full report with details, is now in process of being printed as a Bulletin of the Bureau of Forestry.

(6) Some of the ties treated with the Barschall process have fungi growing on the ends. There are, however, a lot of ties which were poorly treated, and it is not thought that the appearance of these fungi on the ends warrants the conclusion that this treatment will not protect the timber against decay. Another year ought to be allowed to elapse before any definite conclusion is drawn.

PROGRESS IN TIMBER TREATMENT.

During the past year a number of modifications in the treatment of various timbers have been made, of which the following may be noted:

(1) Treatment of Seasoned Pine Timbers with Zinc-Chloride Without Steaming.—The value of seasoning pine timbers before treatment has been urged for a number of years. In hardly any case is timber steamed in Europe before being treated. During the last summer, tests were made at the Las Vegas treating plant of the Santa Fe, with seasoned mountain pine. Absolutely dry, air-seasoned timber was put into the cylinder, and the treatment lasted 3 hrs. 45 mins.

The ties were carefully weighed before and after treatment, and when the treatment was finished they showed an average gain in weight, because of the solution absorbed, of 84.22%. The solution had thoroughly penetrated the wood. This test was repeated a number of times with the same results, and since those tests were made the steaming operation, which is not only a lengthy one, but costly likewise, has been eliminated from the treatment. Similar tests are now under way at the treating plants of the Burlington & Missouri River Ry. in Nebraska and at Somerville, Tex. Attention should be called to the fact that this treatment will only succeed with absolutely dry timber. In view of the fact that the penetration is so much greater and takes place with so much greater rapidity, and, furthermore, in view of the fact that the heating is left out, it is believed to be a great improvement over the present method of treatment. Further tests are now in progress, and the details will be published in full.

(2) Creosoting.—An increasing amount of creosoting is being done at the present time, and the necessity for a careful inspection of the oil is being realized more and more. It is generally being realized that only a good oil will serve the purpose. What constitutes a good oil is a matter which has been much discussed. In spite of many researches conducted in this country and in Europe, it has not yet been decided whether (referring now only to ties or bridge materials) any one of four or five compounds is the essential constituent of good tar oil. What is known, however, is that tar oil, in order to be of a high grade, should have such products in it as will not disappear from the wood when the same is exposed to atmospheric influences, but that will remain in the wood for indefinite periods. Every inspection ought to determine whether the tar oil has this quality of remaining in the wood. This method of inspection should be simple, easy and one which can be rapidly executed by almost anyone. The following set of specifications are being urged by the Department of Agriculture as to what constitutes high-grade oil:

(1) The tar oil must be clear, that is, there must be no substances in suspension. This is best tested by putting a drop of the oil on a piece of filter paper. The resulting spot must be clear and translucent. (2) The specific gravity must be about 1.04 to 1.05 at a temperature of 20° C., 68° F. (3) Boiling points: Up to 150° C. nothing must come off; up to 200° C. not more than 10% may come off; up to 235° C. not more than 25% may come off; up to 355° C. at least 90% must come off. (4) The oil must be absolutely soluble in benzine or absolute alcohol.

Rüping Process of Creosoting.—This process aims to save a certain portion of the creosote now injected into the timber, thereby cheapening the process. Its method of operation may be briefly stated as follows: Absolutely dry air-seasoned wood is put into a treating cylinder, and compressed air pumped into the cylinder up to 5 atmospheres; this pressure is kept about one hour. Tar oil is then pumped in under a pressure of about 85 lbs. until the cylinder is full, and the pressure is then raised to 14 or 15 atmospheres. This pressure is left on until the wood has absorbed as much of the oil as it can. The pressure is then taken off entirely, the oil is run out, and a vacuum is created. The compressed air contained in the wood cells then presses out any excess oil not held by the fibers of the wood. It is claimed that this process saves practically 50 to 60% of the quantity of oil ordinarily used for the treatment. Trial tests, made at Norfolk, Va., by the writer, and similar tests made near Berlin during the past summer, have, to a large extent, sustained these claims. Extensive tests are now under way with this process, and should it prove practical to treat American timbers so that they will absorb only a small quantity of tar oil and still give extensive penetration, this process would recommend itself highly. It would mean treating timbers, with creosote for about the same price that it now costs to treat with zinc-chloride.

Chrome-alum Process.—This is invented by Kester, of Munich, who states that the chief difficulty with salts of various kinds used for treating timber has been that the salts are soluble in water, and leach out. For a preserving solution, he uses chrome-alum and acid-sodium sulphate. These two salts, when in solution cold, do not unite but when the solution is heated to 80° C., the two salts unite and form an insoluble chromium salt. The manner in which this process is operated is as follows. The two salts are mixed in solution (cold) and are pressed into the wood under a pressure of about 4 atmospheres. Steam is then turned into the cylinder for the purpose of heating the wood, and when the same is heated to about 70 or 80° C., the insoluble chromium salt is precipitated in the wood cells. The inventor claims that the treatment can be made for about 7 cts. per tie. No practical tests have yet been made with the process beyond the treatment of 25 ties by the Bavarian State Railways during the past summer.

Giussani Process.—This is a process for which two large plants are now in operation on the Italian railways. The treatment depends upon heating the air in the wood so that a portion escapes, making a partial vacuum. The wood is then dropped into a cold solution of tar oil or zinc-chloride, thereby bringing about a penetration of the preservative. The manner in which the treatment is carried on is as follows: The ties are plunged into a hot bath of tar oil by automatic machinery and slowly moved through the tank for varying periods of time, when they are dropped into a tank containing cold tar oil. The hot oil having heated the tie, when it is dropped into the cold oil a partial vacuum is made in the tie, and the cold oil rushes in, securing a penetration of 2 to 3 ins. This process recommends itself because the plant required is very much cheaper than for the cylinder process. Tests are being planned with this process to determine the relative cost of treatment between it and the old cylinder process.

MECHANICAL DEVICES FOR PREVENTING WEAR OF SPIKES.

A device has been in use in Europe for some years which has given such remarkable results that it is worthy of attention in this country. The great trouble with soft ties is, and always will be, the rate with which the wood around the spikes wears out. Treated ties of softer pines and the inferior oaks are rapidly wearing out at the spike holes, necessitating respiking, and in many instances the entire removal of the tie, because of the decay which sets in at the spike holes. The device spoken of, which is called a screw dowel, or trenail, has now been in use in Germany and France for some five years, and has given the most satisfactory results. The screw dowel consists of a cylindrical piece of beech wood, provided with a broad thread. The upper part of the dowel is somewhat larger than the body. A hole somewhat less than the diameter of the screw or spike is bored through the center of the dowel. The dowel is heavily creosoted. The dowel makes a perfect fit with the tie and prevents the water from getting into the space between the dowel and the tie. The screw or spike is inserted into the dowel much as it would be screwed or driven into the tie. Should any of the wood around the spike wear out, the dowel is removed and another is screwed in its place. The body of the tie is thereby saved from destruction. The tops of the dowels at the same time act as tie-plates, preventing the wearing out of the wood of the tie, and in many cases have rendered the use of the expensive steel plate almost unnecessary. The dowels, when made in quantity, are extremely cheap and it is believed that they ought to prove a valuable means for making possible the use of the softer wood timbers in this country.

Track.

This committee was instructed by the Board of Direction to confer with the Committee on Rails on the subject of standard drilling. This joint committee agreed to recommend the following:

End of rail to center first hole, 2 13-32 ins.; first and second holes, and second and third holes, 5 ins. c. to c. Diameter of hole in rail to be 3-16-in. larger than diameter of bolt used. The punching in splices to be alternately oblong and round, to permit staggering the bolts

Fig. 8. Four-Story Brick Building with Fireproof Shutters.

in rail high enough to allow it without flange interference. The round hole (diameter) to be 1-16-in. larger than the diameter of bolts over thread.

It is generally conceded that for variations of temperature from — 30° to + 120°, a 30-ft. rail will expand about ⅜-in. If the center remains stationary, half of this, or

3-16-in., will be the movement at each end, and the 3-16-in. between diameter of bolt and hole in rail will just permit this. There is a tendency among some engineers to reduce this allowance in the heavier rail now being used. At the same time, there is a tendency toward rails 33 ft. long, so that it is probable the above-mentioned allowance will still be satisfactory for the 33-ft. rails. Where 45-ft. or 60-ft. rails are used, a corresponding allowance for expansion will have to be provided for.

Your committee was requested to report on the current practice and advisability of blocking frogs, guard rails and switches. Replies received from 87 roads, representing about 140,000 miles, favor blocking in the proportion of about 3½ to 1. Some of these favor only metal blocking, attached securely to the rail, but while the very best obtainable should be used, any blocking is better than none, as tending in some measure to prevent loss of life and limb. The experience of those who have used the oak blocking, cut to fit the rail-section and applied with carriage bolts, is very satisfactory.

The heels of frogs should be made with a steel filler block, to fit the section of rail securely bolted in, with the outer end of filler planed off ⅝-in. below top of rail, to act as a riser for the outer edge of worn treads. The wings and throat of all frogs should be blocked with a metal or wood blocking, shaped to fit rail-section; giving 1½-in. flange clearance, and securely bolted to frog.

Garrett Davis, E. H. Lee, F. R. Coates, John Doyle, C. B. Hoyt, D. MacPherson, G. A. Mountain, J. C. Sesser, Committee.

Wooden Bridges and Trestles.

SPECIFICATIONS FOR PILES AND TIMBER.

PILES.—All piles of whatever kind shall be cut from growing trees, free from wind or heart shakes, large or unsound knots, decay or other defects which would impair the strength of durability of the pile. Only butt cuts, cut about the ground swell of the tree, and with both ends cut square, will be accepted. They shall be peeled of bark and the knots trimmed, and the specified sizes shall be, after peeling, straight and uniformly tapering.

OAK PILES.—Shall be of the variety of white, burr or post oaks, with wood of close, firm grain, and with a sap ring not over 2 ins. thick. They shall be not less than 12 ins. diameter at 6 ft. from the butt, and when 28 ft. or less in length they shall be 10 ins. diameter at the top or small end, and where 30 ft. in length or longer shall be not less than 9 ins. at the top.

NORWAY PINE AND TAMARACK PILES.—These shall not be less than 14 ins. nor more than 18 ins. diameter at the butt, and where 36 ft. or less in length shall be not less than 10 ins. in diameter at the top, and where over 36 ft. in length shall not be less than 9 ins. at the top.

LONG LEAF PINE PILES.—These shall be strictly long-leaf southern or yellow pine, and no doubtful grades will be accepted. They shall be hewed square, with all the sap removed. They shall be not less than 12 ins. or more than 14 ins. square at the large end, or 8 ins. square at the small end, and must be smoothly hewed without large or deep score hacks.

CEDAR PILES.—These shall be of white or red cedar. White cedar piles shall be not less than 14 ins. diameter at the butt and 9 ins. at the top where less than 30 ft. in length. Where over 30 ft. in length, they shall be not less than 8 ins. diameter at the top. Unsound butts will be accepted if the defect is not more than 5 ins. diameter, and there must be at least 5 ins. of sound wood all around the defect. Red cedar piles shall be not less than 12 ins. at the butt and 8 ins. at the top.

TIMBER.—All timber of whatever variety shall be cut from sound live trees, and shall be sawed full size, square in section and out of wind. It shall be free from wind shakes, large or unsound knots, pitch seams, decay or any other defects which would impair its strength and durability, and shall generally be free from sap.

LONG LEAF PINE.—This shall be of the variety known as long-leaf southern or yellow pine, and no loblolly or other doubtful grades will be accepted. The wood must be close, firm grained and free from red heart or red-heart streaks; sound knots not over 1¼ ins. diameter will be allowed, but knots must not be in groups. Sap wood will be allowed on one or more of the four sides to an extent of not more than 15% of the surface of any one side, and at any one point throughout the length of the piece.

FIR.—This shall be of the variety of Douglas fir, sometimes called Oregon or Washington fir, and may be the yellow or red varieties, preferably the first. It shall not have at any point of its length and at any edge sap wood more than 2 ins. in width, and shall be free from knots over 1½ ins. diameter, except that in long stringers sound knots not over 2½ ins. diameter will not be cause for rejection if not more than 4 ft. from the end.

D. W. Lum, C. F. Loweth, F. M. Bisbee, H. G. Fleming, W. A. Grondahl, F. P. Gutelius, J. C. Haugh, Theo. D. Kline, W. I. Lee, C. C. Mallard, F. C. Miller, A. F. Robinson, O. J. Travis, Job Tuthill, I. O. Walker, Committee.

Fences and Cattle-Guards.

So universal for railway purposes has become the use of the woven and barbed wire fences that this report is practically restricted to the consideration of fences of that description.

Your committee recommends the use of woven wire in preference to barbed wire, and suggests gage No. 7 for top and bottom wires; No. 9 for intermediate wires, and No. 11 for stay wires. There should be nine wires, spaced 4, 4½, 5, 5½, 6, 7, 8 and 9 ins.; the bottom wire to be 3 ins. above the ground; the spacing of the stay wires to be 12 ins. apart. This gives a 49-in. weave, the top wire coming 52 ins. above the ground. The weight of this fence will be 12½ lbs. per rod, 76¼ lbs. per 100 ft., and 4,030 lbs. per mile. Heavier top and bottom wires are recommended than are generally being used. The life of the fence largely depends upon these two wires, and both are subject to greater strains than the other wires, the bottom wire in addition having excessive corrosive influences to contend with.

While your committee recommends as a standard the woven wire fence, the following recommendations are made for the construction of the barbed wire fence where used. For a hog-proof fence, the first four wires to be "thick set," with four-point barbs, 3 ins. apart, the spacing of these wires to be 3, 4 and 5 ins., respectively. The next four wires to be "regular" or "cattle," with two-point barbs, 5 ins. apart, the spacing to be 6, 7 and 8 ins., numbering upwards. The top wire to be No. 7, plain wire, 8 ins. above the next lower wire. The bottom wire to be 3 ins. from the ground. If a plank is used at top, 1 × 6 ins. is recommended, to be nailed to the face of the post, in which case the top smooth wire and the next lower barbed wire should be omitted. A bottom plank is not recommended on account of its being subject to rapid decay and liable to be burned by fires on the right of way. If difficulty is found in maintaining a hog-proof fence with the spacing of wires recommended, the introduction of vertical stays is suggested; these stays to be of No. 7 wire, spaced not more than 3 ft. apart.

For a cattle-proof barbed wire fence, five wires, spaced from ground to bottom wire 6 ins., and remaining wires spaced 10, 12, 12 and 12 ins. is recommended, the wires to be "regular" or "cattle," with single barbs 5 ins. apart.

It is to be understood that these recommendations are made from a construction standpoint only, and should be considered in connection with the statutes of each state in which the fencing is done. The wires should be placed on the side of the post away from the track, except on curves, where they should be so placed that the pull of the wires is against the post.

All wires and staples should be thoroughly galvanized. Attention is called to the fact that there is a general and apparently well-founded complaint in regard to the rapid deterioration of the so-called galvanized wire.

A. S. Baldwin, E. G. Ericson, H. Baker, C. F. Blue, C. H. Ewing, T. L. Hanley, A. G. Norton, W. D. Williams, Committee.

Records, Reports and Accounts.

The committee believes that printed blanks for bridge office records are not necessary on small roads, because such information is required only once or twice a year, and a suitable blank may be readily prepared by the clerical force. However, large systems of railways, having several grand divisions and many minor divisions, require uniformity in the methods of reporting information for the use of general officers, and on some roads printed pamphlets are distributed to the proper officers on the different divisions, to be filled in periodically with the desired information.

The committee believes that to a large extent the economical working of the bridge department depends upon the completeness and accuracy of its records, and, keeping this fact in mind, as well as the proposition that every working bridge department is to some extent a part of the chief engineer's department, the proper conduct of whose work is dependent upon accurate and complete bridge records, the Committee recommends that the general subject of bridge office records should receive further study before the association is asked to approve any forms for reporting information.

CONCLUSIONS.—In bridge inspections there should be a clear distinction made between current inspection and general inspection. The purpose of the current inspection is to keep the structure in safe condition, to promptly discover any defects, and to report same promptly so that repairs can be made before the safety of the structure is affected. It is important that a simple record should be made while at the bridge and the superior officer kept advised of all such inspections promptly, whether made by a bridge mechanic, gang foreman, division bridge inspector, master carpenter, or others.

The purpose of the general inspection, frequently called the annual inspection, although in many cases conducted semi-annually, or even quarterly, is not only to check the maintenance work of the division organization, but to make a more careful investigation of important bridges and structures on the entire road, and, further, to ascertain and settle what extensive repair work or renewal work should be done in the following working season.

The general forms of the railway should be used in all departments, including the bridge department, as far as applicable; for example, one form for reporting time should be used in all departments, the blank being designed accordingly.

Edwin F. Wendt, Walter G. Berg, H. F. Baldwin, M. L. Byers, W. S. Kinnear, F. L. Nicholson, F. W. Scarborough, J. E. Turk, H. A. Woods, E. K. Woodward, Committee.

Water Supply.

The water used in boilers is practically limited to that found in the territory in which the railways are located. While it is, of course, possible to haul water, yet the expense of this is almost prohibitive, except in extreme cases.

In locating water-supply stations it is, as a rule, advisable to avoid taking water from wells, if water can be obtained from lakes or streams. Well water usually has a bright, clear appearance, and for that reason is often selected in preference to river water that may contain suspended matter at certain seasons; yet the well water may contain in solution so much solid matter, which will be deposited in the boilers, that its use will prove to be very expensive. A certain railway runs for several hundred miles close to the bank of a large river, the water of which is unusually soft and good for boilers, yet the water supply for this railway was taken largely from wells that produced hard water. When this line was absorbed into a larger system, one of the first changes made was to abandon the wells and use water from the river.

The scale-forming and corrosive impurities cause most of the trouble with water in boilers. The impurities of these two classes can be removed from the water before it is put into boilers by proper treatment with chemicals. In most localities the principal trouble is due to the carbonates and sulphates of lime and magnesia that are in solution, causing the water to be hard.

The hardness of water is often described as temporary hardness and permanent hardness. By temporary hardness is meant that due to the carbonates of lime and magnesia. This hardness can be removed simply by boiling the water. By permanent hardness is meant that due to the sulphates of lime and magnesia. This hardness cannot be removed by boiling. If these compounds of lime and magnesia are removed from water it will soften. They can be precipitated by treating the water with chemicals. Any matter in suspension in the water will at the same time be precipitated.

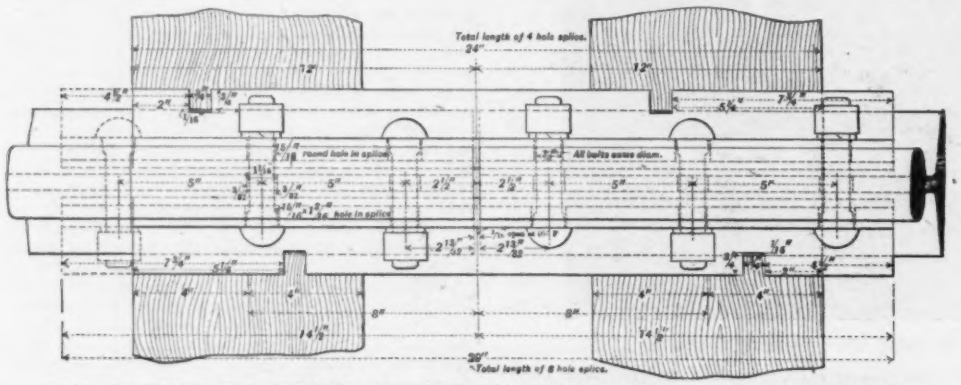
To precipitate lime and magnesia carbonates from hard water it is only necessary to remove from the water the carbonic acid gas that holds them in solution. Common slaked lime is the cheapest known chemical that will do this and not leave any byproduct in the water.

To precipitate lime and magnesia sulphates from hard water it is necessary to decompose them. Carbonate of soda, commercially known as soda ash, is the cheapest known chemical that will do this. It leaves dissolved in the water as a byproduct sulphate of soda. This does not form scale.

The process of water-softening may be divided into two parts: (1) Mixing with the hard water the proper quantity of slaked lime required to precipitate the carbonates of lime and magnesia and also the proper quantity of soda ash required to decompose the sulphates of lime and magnesia. The hardening matter is thus taken out of solution but left in suspension. (2) Separating the matter in suspension from the softened water. The process, therefore, is a mechanical as well as a chemical one.

WATER-SOFTENING PLANTS.—There are two general types of water-softening plants, namely, the intermittent type and the continuous type.

In the intermittent type the hard water is mixed with the proper quantity of chemicals and the mixture allowed to stand in one or more large tanks or reservoirs until the solid hardening matter that is thrown out of solution by



PLAN OF FOUR-BOLT AND SIX-BOLT RAIL JOINT RECOMMENDED BY COMMITTEE ON TRACK; AM. RY. ENG. & M. OF W. ASSOC.

the chemicals has settled. The clear softened water above the precipitated solid matter is then drawn off, generally through a suction pipe attached to a float, and used at once or stored in a supply tank. When after some weeks it becomes necessary to remove the precipitated solid matter from the tanks or reservoirs, it is diluted with hard water and allowed to run out through a hole in the bottom.

In the continuous type the top of the apparatus is located above the top of the supply tank. The hard water and chemicals are mixed at the top of the apparatus and then passed through one or more chambers that are provided with plates or other devices designed to collect the

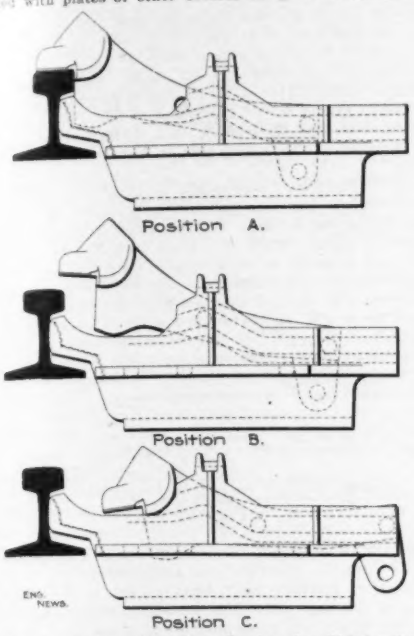


Fig. 1. A New Derailing Device for Sidetracks. Hayes Track Appliance Co., Geneva, N. Y., Makers.

precipitated solid matter and deliver it at the bottom of the apparatus, from whence it is discharged daily. The soft water generally passes finally through a filter and is discharged into a supply tank.

The cost of a water-softening plant set up ready for use varies from, say, $2,000 to $10,000, or more, depending largely upon the type of plant, its capacity and local conditions.

The principal item of expense of softening water is for chemicals. The item of labor is small, because the little extra labor required—such as weighing out the chemicals—is usually done by the regular pumper. The amount of chemicals required varies according to the quantity of lime and magnesia compounds that are to be removed from the hard water. The character of these compounds also affects the cost. If the hardness is due to carbonates, such hardness is removed by the use of slaked lime alone, and the cost, therefore, is much lower than if the hardness is partly or wholly due to sulphates, which are removed by the use of soda ash. The average cost for chemicals required to soften the railway water supply in the territory between Chicago and the Missouri River is 1.4 cts. per 1,000 gallons.

Some of the benefits derived from the use of soft water in boilers are as follows: (1) Hard scale and corrosion; (2) less fuel consumed; (3) decreased boiler repairs; (4) more time in service; (5) more satisfactory service; (6) fewer boilers in service; (7) longer life of boilers.

J. L. Frazier, O. D. Richards, J. A. Barnard, G. M. Davidson, F. A. Delano, Paul Jones, W. A. McGonagle, S. D. Pugh, C. A. Wilson, Committee.

PAVEMENT MILEAGE IN PORTLAND, OREGON, is given in the Mayor's annual report for the year 1903, as follows:

	Miles.
Asphalt pavement	3.13
Macadam pavement	44.60
Gravel pavement	53.62
Stone pavement	4.22
Plank pavement	16.67
Bridges	7.70
Wood block pavement	1.70
Graded streets, unpaved	78.46
Brick	0.62
Total	210.71
Wood sidewalks	337.55
Concrete, stone, brick and asphalt sidewalks	39.19

A NEW DERAIL FOR SIDE TRACKS.

A derailing device to prevent trains and cars on a side track from fouling the main track when the switch is set for the latter, is now very generally used, and the accompanying cuts represent a device of this kind which is already in somewhat extensive use. The special features claimed for it are that it is very simple and inexpensive, it is not affected by snow, it leaves the track rail unbroken, and it operates in such a way as to be reliable in action and economical in maintenance.

The device consists essentially of two parts: 1, the derail proper, traveling on pins; 2, the base, which is attached to the ties and has an inclined grooved path. It is made of malleable iron and weighs 105 lbs. The derail is connected to the switchstand. When the switch is set for the main track, the head of the movable derail rests on the side track rail, as shown at A, in Fig. 1. When the switch is set for the side track, the switch connections draw back the derail, and the shape of the grooved path is such that the derail first rises above the rail, as shown at B, and then drops below it, as at C. The view in Fig. 2 shows the derail in position with the switch set for the main track, and also shows it connected to an interlocked dwarf signal. The derail and detector bar are operated by a pipe line from the tower; a second connection from the derail runs to the wire bolt-lock which controls the signal. The extra force at the lever to operate the derail is said to be hardly noticeable. It will be noted that a derailed wheel will fall clear of the device.

This derail was invented a few years ago by Mr. S. W. Hayes, M. Am. Soc. C. E., then Engineer of Maintenance-of-Way of the Cleveland, Cincinnati, Chicago & St. Louis Ry. He received instructions to equip a large number of side tracks with derails, but as split-switch derails were expensive in first cost and maintenance, attention was given to the design of a device which would be more economical and equally efficient. The derailing device above described was evolved, in a rather crude form, and several were put in service. Afterwards, when its advantages became apparent, it was perfected and patented. The C., C., C. & St. L. Ry. has so far bought 300, and other roads have bought smaller numbers; these latter include the Pennsylvania R. R., the Terminal R. R. Association of St. Louis, the Alabama Great Southern Ry., and the Brooklyn Heights St. Ry.

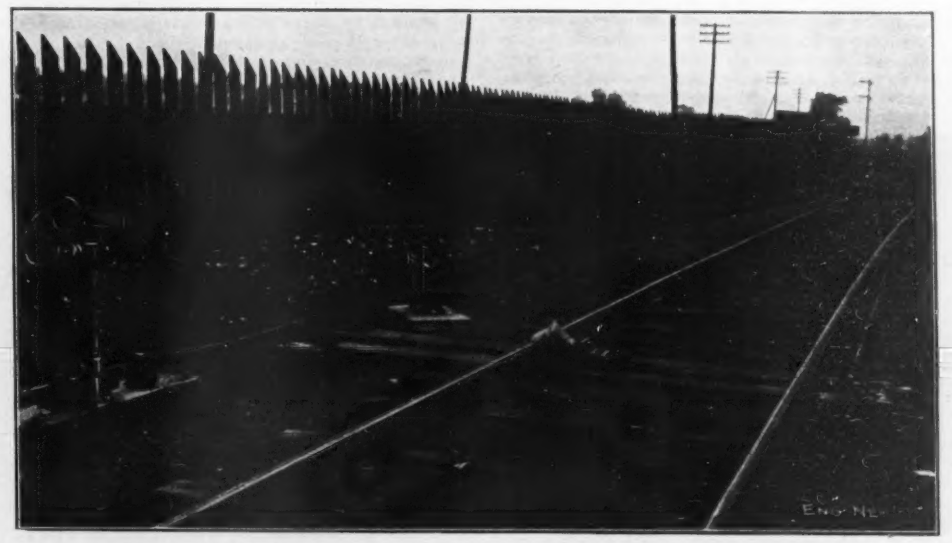


FIG. 2. HAYES DERAILER CONNECTED TO AN INTERLOCKING PLANT.

Until a few months ago it was manufactured to order, but it is now being made and introduced by the Hayes Track Appliance Co., Geneva, N. Y. The following is the substance of a letter from the Cleveland, Cincinnati, Chicago & St. Louis Ry. in regard to a practical experience with the device:

This lifting derail is just the thing, and for some time we have been using it exclusively at interlockings, except in the main tracks, where we are still using a switch derailing device. We contemplate, however, putting a simpler and cheaper derailing device in our main tracks. There is no reason why this will not answer. If there is any doubt, we could put one on each rail. We have had, unfortunately, a great many trains and engines derailed with these devices, and they are as positive as anything we know of. We have never had one fail to derail. They are thoroughly adaptable to almost any kind of connection. Any switchstand that will give 5 ins. throw to the rod will operate the derail. The cost is very light, the labor of installing is light, and the maintenance is almost nothing. The best thing about it is that it is less affected by snow and ice than any derail or derailing device we have ever seen. Most derails, in bad weather, are a menace and seem to derail too often when they should not.

THE CONSTRUCTION AND OPERATION OF COAL PIERS.*

Coal piers used by railways for handling coal from cars to vessels are variously known as coal piers, coal docks, coal wharfs, coal trestles, coal chutes, coal dumps, coal tipples, etc. They may be divided into two general classes: (1) Piers where coal is elevated by machinery and then run by gravity into boats, or handled by machinery entirely. (2) Piers where coal is handled from cars to boats by gravity, i. e., where the car is raised to such elevation as to allow the coal to run by gravity into boats. Combination coal and freight pier is in use by the Louisville & Nashville Ry. at Pensacola.

In the handling of coal it is important to prevent its breakage, as far as possible, but this breakage must occur more or less, and unless special care is taken this may result in great loss. The larger lumps are broken up and a quantity of chips and dust is produced. As some of this fine stuff is lost and some of it is not used, there is a loss in the actual quantity of the coal. And since the smaller coal sells at a lower price, there is also a loss in quality. The above applies particularly to bituminous coal, since this is softer and more fragile than anthracite, and contains much more volatile matter. Anthracite coal is, of course, subject to the same deterioration, but in less degree. At points where coal is shipped in great quantities, deterioration by breakage is an important matter, as it affects every ton of coal handled, and virtually increases the cost of handling the coal by the amount the coal loses in value and quantity. Means for reducing the breakage of coal in handling it, both by machinery and by gravity, at coal shipping piers, are noted in this report.

(1) PIERS WHERE COAL IS HANDLED BY MACHINERY.

This type of pier, although especially adaptable under certain circumstances, is not in general use. The most common examples of these piers are where the cars are elevated and tilted bodily by machinery, and some of these piers and car-dumping machines are described later on in this report. Another type is where the coal is dumped from cars into a hopper and then elevated by means of an endless-chain elevator, or scraper, to such height that the coal will run into the boats by gravity. The operation is similar to that employed at many locomotive coaling stations. This type is adaptable to those locations where the upland, back of the pier, is limited, i. e., where there is not room enough to turn the cars so that they can be run on the pier. An example of this case is where the supply track runs at right angles to the pier and close to the shore end. Some plants of this type are noted further on in this report.

(2) PIERS WHERE COAL IS HANDLED BY GRAVITY.

This type of pier is by far the most common and it is

*Abstract of a committee report prepared for the annual convention of the American Railway Engineering and Maintenance of Way Association at Chicago, March 15 to 17. Committee: W. G. Besler, E. E. R. Tratman, J. A. Atwood, M. S. Blaiklock, E. P. Dawley, C. F. W. Felt, F. O. Metcher, G. F. Morse, C. S. Sims, F. S. Stevens.

adaptable to almost any location. There are two general layouts for these piers:

(A) Piers having berths or water on one side only, such as a pier alongside of a canal. (B) Piers having berths or water on both sides, such as piers running out into the water, square with the upland. These two layouts are further divided into: (1) Piers having locomotive inclines, or where the cars are placed on the upper level by a locomotive. (2) Piers having inclines up which cars are hauled to the upper level by means of a cable and stationary engine. (3) Piers where cars are run onto the pier at the upper level by gravity.

(A) PIERS HAVING BERTHS ON ONE SIDE.

(A1) PIERS WITH LOCOMOTIVE INCLINE.—The simplest example of this type of pier is where cars are placed by a locomotive and taken away again by the same means. (Fig. 1.)

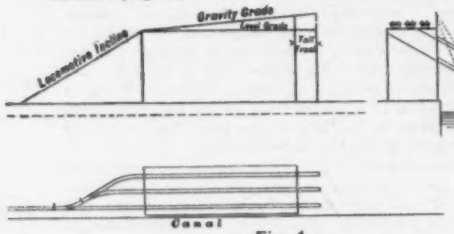
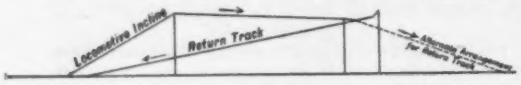


Fig. 1.

In the case of a level upper deck the cars have to be placed by the locomotive over the pockets, or chutes, into which the car is to be unloaded, or they must be moved along by the aid of pinch bars. Another form of this same type of pier is to have the top deck on a grade, so as to be able to move the cars to any particular pocket by means of gravity. The top deck can be sloped in either direction. In cases where the top is sloping in the direction of the locomotive incline, cars can be placed by the locomotive on the "tail tracks" and "spotted" by gravity over the proper pocket. In this case, when the locomotive incline is not too steep (preferably not over 2½%), the empty cars can be let down to the yard level by gravity.



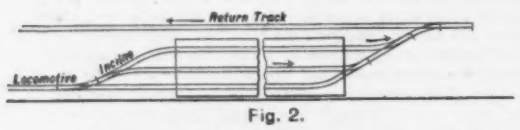
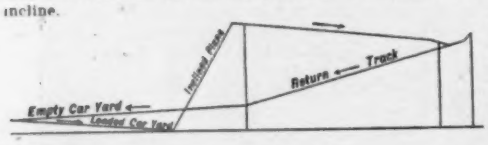


Fig. 2.

Another type of pier similar to the one above described is where the cars are placed on the upper deck by the locomotive and the empties are returned to the yard level by gravity. (Fig. 2.) This can be accomplished by placing the return track on the opposite end of the pockets to the locomotive incline, or by means of a switchback the cars are returned to the same end as the locomotive incline.



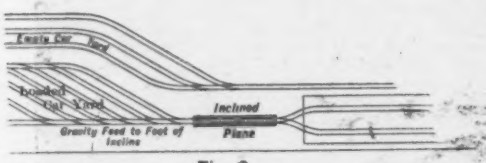


Fig. 3.

(A2) PIERS HAVING INCLINED PLANES AND BERTHS ON ONE SIDE ONLY.—This type of pier is similar to those described above, except that the inclined plane replaces the locomotive incline. (Fig. 3.)

Another form of this same type of pier is to place the inclined plane at the side of the pockets, as shown in

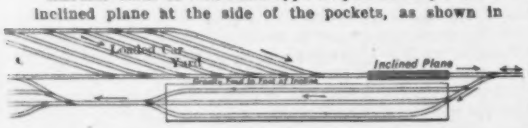
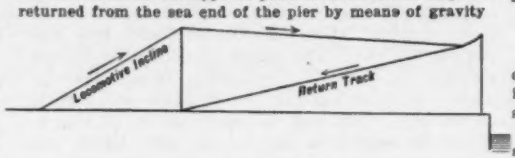


Fig. 4.

Fig. 4. This form has the advantage of being able to get suitable yard tracks ahead of the plane when the length of the layout is limited. A further advantage is that in case of accident to the machinery operating the inclined plane, the pier can be operated from the return track incline by a locomotive. In this case the pier takes on the characteristics of a pier described under the head of A1. The supply tracks (loaded-car yard) should be so arranged that cars will feed to the foot of the incline plane by gravity.

(B) PIERS WITH BERTHS ON TWO SIDES.

(B1) PIERS WITH LOCOMOTIVE INCLINE.—The simplest type of this kind of pier is arranged similar to pier shown in Fig. 1, with berths arranged on each side. Where the top is level, it is objectionable on account of not having the assistance of gravity for moving the cars. Another form of this type of piers is to have the empties returned from the sea end of the pier by means of gravity



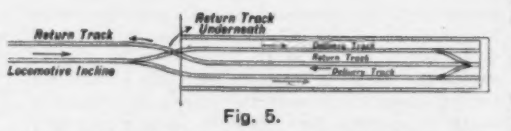


Fig. 5.

and a switchback (Fig. 5). Piers of this design usually have three or five tracks, the middle track (or "well track") being used as the return track.

Another arrangement for this type of pier is to have the locomotive incline placed on the pier, delivering the cars to the upper level at the sea end. The empties are returned by gravity to the yard at the shore end (Fig. 6). The advantage of this arrangement is that the sea end is made the high point of the pier and the location of the high chutes. This is desirable, as it locates the berths for the large vessels at the sea end, which is the proper place for them. Another advantage of this arrangement, especially in the case of long piers, is that a very low grade incline can be used, thus increasing the tonnage a locomotive can place on the upper deck per trip. This type of pier also economizes in space longitudinally; the shore end being the low point, space is saved in the length of the return incline.

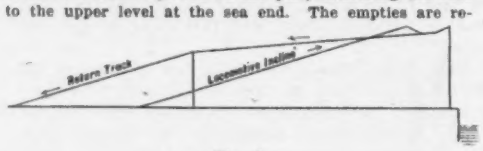


Fig. 6.

(B2) PIERS WITH INCLINED PLANES.—Inclined planes are usually resorted to where the room ahead of the pier is not sufficient for a locomotive incline. The usual practice is to have two inclines, one for each side of the pier. The pier is operated by gravity, and empties are returned by means of a switchback at the sea end. In all other respects, excepting the incline plane which replaces the locomotive incline, the pier is operated the same as described under head of B1 (Fig. 7). The supply tracks or loaded-car yard should be so arranged as to feed cars to the foot of the incline by gravity.

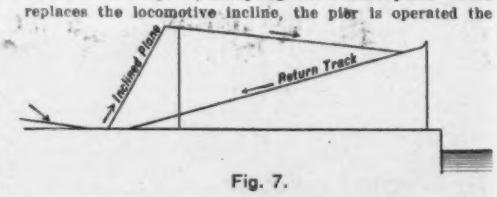


Fig. 7.

Another form of this type of pier is to place the inclined plane at the sea end, as shown in Fig. 8. This arrangement is particularly advantageous where the upland is limited and of sufficient height to feed cars to the foot of the plane by gravity. It has the further advantage of reducing the width of the pier. The location of the supply track, which is generally placed in the middle, is such that it does not require an open well. The tracks on the upper deck can be carried across the full width of the pier, except for the hole where the incline plane elevates the cars. The saving in width of pier for this arrangement is about 12 ft. for the entire length of pier. This type also economizes in space longitudinally in cases where the general yard level is high. The shore end being the low point of the pier, the cars are returned about to the elevation of the yard.

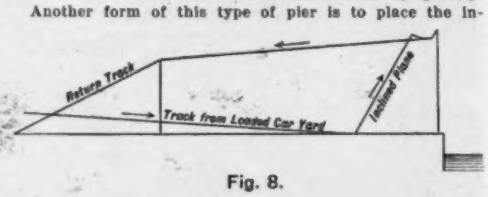


Fig. 8.

(B3) PIERS OPERATED BY GRAVITY.—It sometimes happens that the piers are located where the upland back of the piers is high enough so that cars can be run on the upper deck by gravity (Fig. 9). This arrangement is obviously the most economical in operation.

SCALES.—Track scales should be provided for each pier where the business warrants it. The location of the scales can be either at the head of the pier on the upper deck,

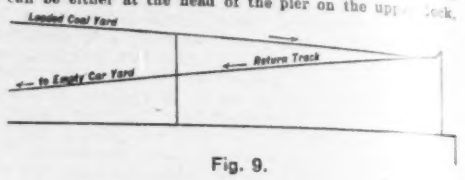


Fig. 9.

or at the entrance of the loaded-car yard. At some piers it is necessary to weigh the empty cars. In this case scales should be on the return track also.

VERTICAL CURVES.—In all cases vertical curves should be provided for at the change of grade. In length the curves should extend over three or four bents, or for a distance of from 35 to 50 ft., and, where circumstances will warrant it, it is desirable to have longer vertical curves.

SWITCHBACKS.—These should be made so as to work automatically. The usual method is to have a spring in head rod of the switch. In some cases, where room is limited, a transfer table or a pivot table is used. Pivot tables are arranged to work automatically by means of a counterweight. The normal position is in line with the delivery track. Cars are run on the table, and the table moves, by weight of the car, to the return track; the car then moves off by gravity, and the counterweight then returns the table to its first position. (Fig. 10.)

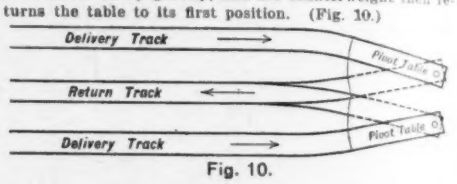


Fig. 10.

GRADES.—The grade for a locomotive incline may be made as steep as about 5%, but seldom above this figure. In practice, however, most piers do not have over 3% grade on the approach. Where steep locomotive inclines are used, it is desirable to have a long track ahead of the pier for the locomotive to get up speed before reaching the incline. The grades on the piers in practice are generally made from 0.8 to 1.5%. It is difficult to determine just what grade to use. In summer time cars in good condition will run freely on a grade as low as 0.8%. In winter time some difficulty is experienced even with higher grades. Usually where a grade is less than 1% a short sharp grade is introduced at the head end of the pier to give an impetus to the cars. It is also desirable to have a short sharp grade where the cars run on the switchback.

Grades of 1 to 1½% for the general grade on top of the pier are demonstrated in practice to be about right for piers in northern climates. Where a lower grade than 1% is used, a short grade of 1½% at the point where cars start to move by gravity is advantageous. Grades for return track can be somewhat steeper than for the delivery tracks, but good practice is to keep the grades below 2%, and preferably about 1⅞%. In practice where inclined planes are used the grades are from 12 to 25%, usually 17 to 22%.

TRACKS ON TOP OF PIER.—Where more than one track feeds a single chute it is desirable to arrange cross-

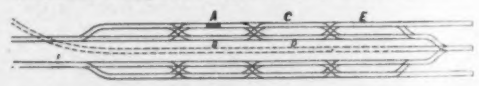


Fig. 11.

overs between the berths, as shown in Fig. 11. By means of these crossovers cars can be passed around any car that has been stopped over a chute for unloading. A car standing at (A) would block traffic on that track. Should a car on the track behind (A) be required at (C) or (E) it can be passed around the car standing at (A) by means of the crossovers on either side of (B).

POWER INCLINED PLANES.—An inclined plane is operated by a cable and stationary engine, usually placed under the incline. There are two systems in use, one using a small car, or "barney," attached to the end of the cable, running on a narrow-gage track between the standard-gage track rails. This "barney" is dropped into a pit at the foot of the plane. Cars are placed ahead of the "barney," and the cable is wound up, the "barney" rising out of the pit and engaging the rear end of the car. By means of the cable both are drawn up to the upper level. The "barney" is hauled back to the pit again by means of a small cable, ready for the next car. The other system is to have a continuous cable, the cars being attached to the cable by means of a short cable, having a hook on one end to engage an eye in the main cable, and a link on the opposite end to attach to the drawhead of the car by a pin. Where the continuous cable system is used the "bull" pulley should be placed far enough ahead of the top of the incline to prevent a downward pull on the drawhead. It is not customary to take up more than one large car at a time.

In most cases where piers have berths on each side and the return track in the middle, there is one incline for each side, with separate drums and engines. These drums are so arranged that the shaft can be connected by a clutch; thus, in case of a breakdown of one engine, the drums can be worked together. It is the practice, however, to use one incline at a time. The men employed on the inclines, both at the top and bottom, including the engineman, cross from one incline to the other as the cars are to be elevated.

SELECTION OF TYPE OF PIER AND APPROACH.

In most cases where inclined planes have been used, the room ahead of the pier is so limited that a locomotive incline for the shore end could not be considered. An inclined plane is, however, an economical arrangement where the tracks ahead of the pier can be arranged so as to feed the cars by gravity to the plane, thus dispensing with the services of a locomotive. Where this arrangement is not possible, and a locomotive is required to feed the cars to the plane, it is more economical to let the locomotive place the cars on the upper deck, if room is available. This arrangement is also more elastic than when the incline is used, as it allows more locomotives to be added when traffic is heavy. One engine can be employed in pushing cars up the incline while others are sorting cars in the yard.

In all cases tracks should be arranged to make the least number of shifting operations in the yard. Usually a large number of short tracks are required to sort cars with the different sizes and kinds of coal. Hence, when this is the case, the loaded-car yard should consist of a number of short tracks or a "gridiron" arrangement with ladder at each end. For the empty-car yard, usually a few long tracks will suffice, as no sorting is necessary. In all cases where steep locomotive inclines are used, a long track should be provided so that the train can get up speed to overcome the grade on the incline.

Where the loaded-car yard is at such a height that cars can be run on the upper deck of the pier by gravity, the loaded-car yard can lead directly onto the pier. Obviously, piers that are so situated that the yard together with the pier can be operated by gravity are by far the most economical.

COAL-CAR DUMPING MACHINES.

For the rapid handling of coal (and ore) from cars to vessels machines have been introduced which pick up the loaded cars (containing 30 to 50 tons of coal each) and dump their contents at once. It has already been explained that in the handling of coal it is important to prevent its breakage into smaller sizes as far as possible, and, while a certain proportion of loss and breakage is inevitable, the car-dumping plants include special provision for reducing this to a minimum. This is done by preventing the coal from dropping or falling freely from any height. It is caused to slide or roll down inclined surfaces, and where vertical chutes are used they are kept so full that the coal "flows" rather than "falls" through them.

THE McMYLER MACHINE (McMyler Mfg. Co., Cleveland, O.)—In the first machines built by this company the cars were dumped endways. The loaded car was hauled up an inclined girder forming a "see-saw" or "teeter-board," the outer end of which projected over the hatchway in the vessel's deck. The car being in position, and held by stops and clamps, the girder was then tilted to discharge the coal through the end of the car. The first machine was installed at Ashtabula, O., and another at Fairport, O.; both of these are still in service. These machines, however, necessitated the use of cars having end gates, and they have been superseded by the side-dumping machines, which can handle any style of coal car. The company has built 14 machines and is now erecting at the Hoboken pier of the Delaware, Lackawanna & Western Railroad the first machine of this type for handling anthracite coal. These machines were built under the supervision of Mr. F. W. Lovell, as Chief Engineer for the McMyler Company.

The style of the latest machine is shown in Fig. 12. It consists of a steel frame and the necessary mechanism for hauling cars in, elevating them and tilting them; also for moving the chute for delivering the coal into the vessels, and for clearing the vessels as they arrive at and leave the machine.

The operation is as follows: The loaded car is placed in the yard and moved to a point near the machine; this is usually done by gravity, but sometimes by an endless rope haulage system. The car is then hauled up the incline into the machine by means of a haulage engine. It is automatically clamped, hoisted to any desired height, and turned over sideways, delivering its contents into an inclined triangular apron, the car being at the base of the triangle. The apron is adjustable as to height, to suit different vessels, and from its apex the coal runs through a vertical chute into the hold of the vessel. The coal simply slides down the apron, and as the chute is quite full the coal has no drop, but flows down in an unbroken stream. The chute is telescopic, so as to be adjusted to any height of the apron or any depth of hold. It is also pivoted, so that coal can be delivered at the sides as well as at the middle of the hold. The apron will hold 70 tons of coal, or two carloads. When the car has been dumped the cradle is lowered, and the car is pushed off by the next loaded car entering.

The machine is usually operated by steam power, and two steam winches are placed on the pier or dock for moving the vessel so that the different hatches will come under the chute. It is designed for handling either anthracite or bituminous coal, and provision may be made in the apron for screening the coal. The machine will handle all sizes of cars found in the coal trade (without any alterations), and will deliver coal into all kinds of vessels. When working under favorable conditions the machine can handle 30 cars or 1,000 tons per hour, and this rate has been attained with the machine of the Cincinnati, Hamilton & Dayton Ry. at Toledo. The force required is given as follows: One man to operate the

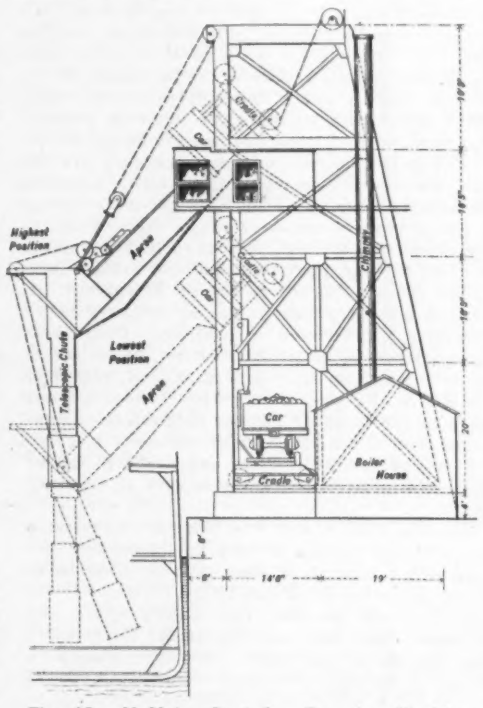


Fig. 12. McMyler Coal Car Dumping Machine.

cradle and apron, one to operate the telescopic chute, one to operate the car-handling machinery, one fireman and one oiler.

THE BROWN MACHINE (Brown Hoisting & Conveying Machine Co., Cleveland, O.).—In this machine the cars are elevated and tilted sideways to discharge their contents, but the car is not raised to a great height and the coal is not delivered directly into the hold of the vessel. The tilting cradle is mounted in a steel house or tower and the operations of the machine are as follows:

When the cradle is in its lowest and normal position, a loaded car is pushed into it by a pushing device (a "barney" or "ground-hog"), which lies in a pit between the track rails, when not in use, and is operated by a cable. When in the cradle the car is clamped by means of hydraulic clamping bars. The engine is then started and the cradle is slowly revolved sideways until the car is upside down. During this movement the coal has rolled, rather than fallen, from the car into six hoppers attached to the cradle, and each hopper has entered a transfer tub, or car, the six tubs standing on a flat car alongside the cradle. The hoppers have bottom doors, which are automatically released on touching the bottoms of the tubs. The cradle is then returned to its normal position, leaving the coal in the tubs, where it has been deposited quietly and without falling, so that there is practically no breakage. The empty car is then run out of the machine by gravity and another loaded car pulled in. In some cases cars can also be fed into the machine by gravity.

As soon as the cradle is clear of the tubs, the car on which they are mounted is hauled away and its place is taken by another car with six empty tubs. Running over the machine, on a runway parallel with the face of the pier, are two overhead steam traveling cranes, having a speed of 600 ft. per minute. These have projecting girders extending beyond the face of the pier, but capable of being moved in and out, so as to clear the masts of vessels. These cranes, which are operated independently of the rest of the machine, take the loaded tubs, one by one, and carry them to a point opposite the proper hatch of the vessel, where they are run out on the girders and lowered into the hold. On touching the bottom of the ship or the top of the coal pile, the doors of the tub are released and the coal rolls out as the tub is hoisted out of the hold again. The crane operator then returns the tub to its car and takes the next tub, until all the tubs have been emptied. The machine operator then returns it to the dumping machine to have the tubs loaded again. The crane operator can dump the tubs in the center of the hatch, or at either side, and can carry the tub to any of the hatches, and can thus keep the vessel in proper trim all the time it is being loaded.

The two cranes can handle 5,000 tons in ten hours, and the car-dumping machine can handle twice this amount, so that by the use of four cranes the plant would have a capacity of 10,000 tons in ten hours. In 1903 one of the machines at Toledo, with two cranes, loaded 6,300 tons into a vessel in ten hours. The machines were first built to handle 30-ton cars, but have since been strengthened to handle 40-ton cars, and those now being built are to handle 50-ton cars. The track layout and the construction of the pier vary, of course, with different conditions and locations. In some cases it is possible to feed the cars to the cradle by gravity and also to deliver them from the cradle by gravity; in other cases it is necessary to use a car-pushing device or "barney" to feed the cars into the cradle. The company has built a number of these machines for dumping coal cars and ore cars.

THE WELLMAN-SEAVER-MORGAN MACHINE (Wellman-Seaver-Morgan Co., Cleveland, O.).—This company has for the last two or three years been building car-dumping machines almost exclusively for inland furnaces for iron ore, but has built one machine for handling coal. It is situated on the Buffalo, Rochester & Pittsburg Ry. dock at Buffalo. On this dock the coal to be handled was of such a nature that it was very essential to reduce the breakage to a minimum. For this reason the machine was built with large conveyor buckets, which carry the coal from the machine and lower it to the bottom of the hatch before dumping. Ordinarily, where it is not desired to look after the breakage so carefully, the machines are built with a chute, which conveys the coal from the machine direct to the boat.

The buckets are designed with a movable bottom, and when in position for receiving coal from the car dumper the bottom is close to the top of the bucket. As the

LIST OF RAILWAY COAL PIERS.

RAILWAY.	Location.	Date When Built.	Size. Feet.	Approach. Method of Elevating Cars.	Approach. Grade Per Cent.	Approach. No. Tr'ks	Gr. of Deliv'ry Tracks On Pier Per Cent	Gr. of Return Tracks On Pier Per Cent.	Gr. of Return Tracks Beyond Pier Per Cent.	Height. Shore End Feet.	Height. Sea End Feet.	No. Tracks on Upper Deck.	No. Return Tracks.
N. Y., O. & W.	Cornwall, N. Y.	1892	ABOUT 50x700	Inclined Plane Sea end		1						4	2
P. R. R. No. 5	Greenwich Pt., Philadelphia	1888	56x650	Loco. Incline Shore end	ABOUT 2.	1	0.3	0.3	2.0	28.	30.	4	2
P. R. R. No. 6	Greenwich Pt., Philadelphia	1902	735x50 to 60	Cable Incline Sea end	17.5	3	1.	2.8	1.5	65.	57.5	2	1
N. Y., S. & W.	Cliffside, N. J.	1893	65x957	Inclined Plane	20.	2	0.87 & 1.22	2.06		31.7	25.	4	1
P. & R.	Port Richmond, Philadelphia	1893	ABOUT 54x700	Loco. Incline	2.95	2	1.39	1.39			ABOUT 23.		
P. & R.	"	1898	55x761	Loco. Incline	1.25		1.25			43.4		4	
P. & R.	Port Reading, N. J.	1891	56 wide.	Loco. Incline	3.	2	1.33	3.		36.	19.	4	2
N. & W.	Lambert's Point, Va.	1890	ABOUT 50x805	Loco. Incline	2.5	1	0.732	2.5	1.0	42.	35.	2	1
N. & W.	" " "	1902	56x850	Inclined Plane	25.	2	0.667	2.833	2.833	72.8	74.6	2	1
D. L. & W.	Pier No. 10, Hoboken, N. J.	1884	64x995	Inclined Plane	16.	2	1.0	0.8		35.	25.	4	1
D. L. & W.	Hoboken	1903	1283x60&72	Gravity	1.		level.	1.	1.	4.5	4.5		2
C. R. R. of N.J.	Jersey City, N. J.	1887	38 wide.	Loco. Incline	2.64	2	1.46	3		29.	20.6	2	1
D. & H.	Weehawken, N. J.	1887		Inclined Plane	17.5	1	1.38 1.04	1.74		35.		4	1
B. & O.	St. George, S. I.	1892	ABOUT 300 long.	Loco. Incline		1	level.						
B. & O.	Philadelphia, Pa.	1893	40x700	Loco. Incline	2.	2	level.			18.5	18.5	2	1
B. & O.	Curtis Bay, Baltimore	1900	800x60	Loco. Incline	1.5	2	1.5	2.5	—1.	45.	45.	2	2
Erie	Weehawken, N. J.	1891		Inclined Plane	20.	2	0.87 1.22	1.4		36.	36.5	4	1
L. V. R. R. Pier A	Perth Amboy, N. J.	1886	70x800	Gravity	0.6	4	0.6	1.0		29.5	25.	4	1
C. & O.	Newport News, Va.	1882	44 wide. 275 long.	Loco. Incline	2.09	2	0.9 0.6	0.6			22.	2	1

bucket is filled the bottom gradually lowers so that the coal does not drop at all. After the bucket is filled it is conveyed over the hatch and lowered to the bottom of the boat, where the top part of the bucket is drawn away from the bottom, allowing the coal to flow out without any breakage. This is illustrated in Fig. 13. Two buckets only are used, their combined capacity being ample for any coal cars now in use.

The car dumper proper is very similar to the McMyler machine and was invented by Mr. G. H. Hulett. The loaded cars are run into the machine by a barney car, which disappears in a pit and allows the loaded cars to pass over and in front of it, when by a haulage engine it is pulled out and pushes the loaded car on to the platform of the car dumper. The car is automatically clamped to position on the platform by means of counterweights, which are hung on chains at the back side of the machine, the chains running through the machine and over the car. The weights are graduated so as to give a pressure sufficient to hold the car in an inverted position without putting an undue crushing strain on the sides of the car. The tracks which are provided for the car on the platform are arranged on a moving table, and the first motion of the car as it starts to invert is sideways, until the side of the car rests against the steel plates forming the sides and chute of the cradle.

The machinery for controlling the tipple and conveyors is mounted on top of the machine. One operator is required for the tipple and barney car, one for each of the buckets, and a fireman. This car machine has handled 26 cars per hour, which is practically the same speed as the machines which dump directly into the boat. The result in regard to breakage has been found very satisfactory. The front end of the conveyors is made movable so that the two booms when extended over the boat may be placed over two adjacent hatches. These hatches are usually 24 ft. centers. The total cost of running these machines, including shifting of cars, fuel, operators and maintenance, has been found to be from $550 to $600 per month. In ordinary use about 4,500 tons of coal are dumped over the machine during ten hours.

THE LOCATION OF THE FIRST DIVISION OF THE HANKOW-CANTON RY.*

By Jesse W. Miller.†

The survey of the first division of the Hankow-Canton Railway was begun at Canton in September, 1902.

The zero of the tide gage of the Imperial maritime customs, at the Custom House, Canton, was taken as the datum of elevation. This gave the field men some trouble later on as they eventually came to minus elevations in river soundings. From the Custom House we carried a line of levels through the city of Canton in the narrow streets to a point half a mile up the river, where the company had acquired a strip of reclaimed land, which they intend to use as a terminus. The streets of Canton are, on the average, 8 ft. wide, winding, and are paved with granite flags worn smooth by the constant stream of barefooted populace ever crowding through them. In order to get the levels through, an instrument was set up, and a mass of about 15 soldiers (the soldiers were provided on request in any number by the prefect) in front and the same number behind, blocked up the street till a backsight and turning point were taken. Meanwhile a cursing, howling mob had congested at either end of the cordon. This was rather trying on the nerves of the instrumentman who was handling an instrument set up on the greasy paving stones. As soon as the crowd had cleared the process was repeated till the work was finished.

The constant attendance of soldiers during the field work was a great nuisance, yet their appearance no doubt prevented many difficulties with the natives. They were, as a rule, a surly, lazy, villainous lot, and rightly is the profession of the soldier held in great contempt in China. They were armed with Mauser rifles of an old pattern, but most of these guns had had the breech blocks rusted in fast on some occasion long gone by. No ammunition was provided them, which fact was perhaps fortunate. An engineer going out to run a line of levels would have two or three coolies to use in clearing the line, another coolie to carry the instrument, and perhaps a Chinese rodman who spoke enough English to act as interpreter. In case an American rodman was on the party an interpreter was carried in addition. Then there was a troop of about 20 soldiers, whose transportation had to be looked after, and who were always in the way of the work. These soldiers were in the habit of helping themselves to anything they could lay hand on whenever they got out of sight of the chief of party. Their service at best was for appearances—a sort of honorary escort.

Between Canton and Fat San the terrain is a series of rice paddies divided by canals and covered with a network of dikes running in all directions. These dikes vary in height from one to ten feet. Canals intersect the country every few thousand feet. The variation of the elevation in this distance of ten miles is not more than 2 ft. except on the dikes and in the streams and canals.

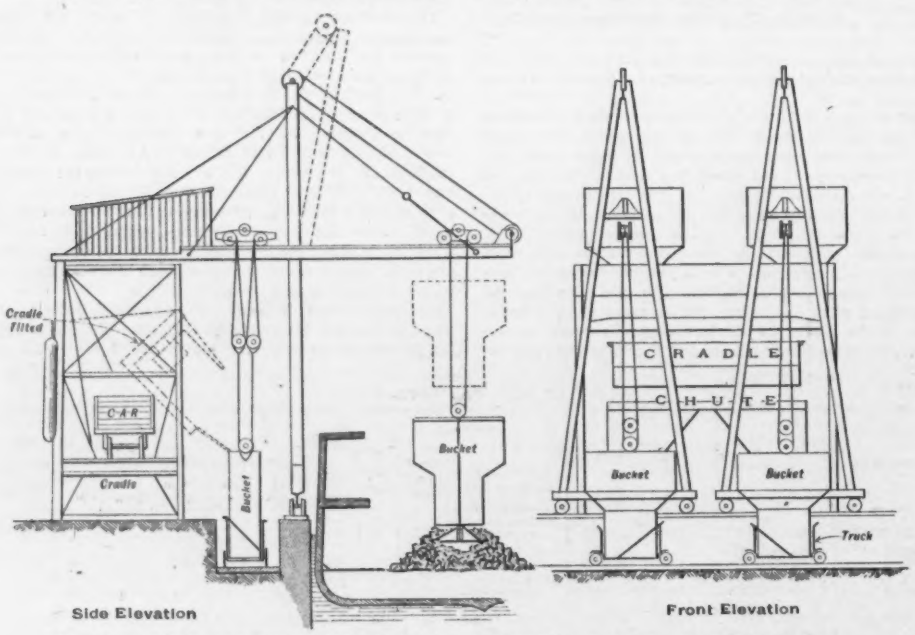


Fig. 13. COAL CAR DUMPING MACHINE; WELLMAN, SEAVER & MORGAN CO.

The elevations of the first and last stations of the line in each rice paddy were determined and the intervening stations were assumed to be the same, as the fields were perfectly water-leveled. Here and there a dry field was met with, which was, as a rule, planted with mulberry cuttings, from which the leaves were gathered as food for the silkworms. Fish ponds and slimy lily pools made the work of the chainmen a dirty job, sometimes they were in the water up to their necks. Chinese chainmen were used and gave good results. It was found advisable for quick work to send an American along with the front rodman to see that the stakes were properly marked and to keep the outfit in motion.

The stakes used were half round pieces made by sawing a pole in two laterally. They were 2½ ins. in diameter and in two sizes, 2½ and 4 ft. in length. Even these could very frequently be shoved their full length into the mud with the hand. Several coolies were necessary to carry a day's supply of this lumber. For plugs we had to have two sizes: one for firm ground and the other when we were compelled to make a set up in the mud. The first size was round, 2 ins. in diameter and 8 ins. long; the second size was 18 ins. long.

Topography was quite difficult. The land is owned in all sorts of irregular-shaped parcels. Frequently there will be a small field not more than 25 × 25 ft. in dimensions which is owned separately by some poor farmer. As a rule all structures are small and are built without any especial relation to each other, so the method of sketch books was found the most available. The instrumentman kept his stadia book, and one topographer took the right of the line and another the left. Each had a large sketch book or sheets of paper, and each was accompanied by a rodman. All shots were dotted on the sketches by number. This work was slow and tedious. Perhaps there is no other topography which requires more detail than this.

According to the concession by the Imperial Government, the right of way and terminal properties are furnished the company free of charge. It seems, however, that there is some sort of an arrangement by which the owners will be reimbursed by receiving stock in the company in payment for their lands.

The line was projected first on a small scale map, said to have been made by a native more than a hundred years ago. It was found to be quite accurate. Other preliminary maps of the region immediately about Canton were made by triangulating to various objects from the high pagodas with a prismatic compass, and then stepping off the distances or timing boats. These rough maps were made in this manner so as not to disturb the natives by too great a display.

To show how ordinary things are frequently forgotten, when the line was started we found that there was an abundance of everything for field work but "keel." A few sticks of lumber crayon would have commanded a high price at that psychological moment. As a substitute the ordinary Chinese brush-pen and native ink made in sticks which had to be ground in water in a small dish. Considerable valuable time was lost in this process.

We never succeeded in teaching the Chinese how to use an American axe. Perhaps some one has done better later. They were willing enough to peck away at a tree with a hatchet, but when it came to the genial sweep of the axe that bites out a large chunk, they failed to rise to the situation. One coolie who had formerly been employed on an American cruiser made quite an efficient level rodman after a few weeks' experience. The front rodman on the transit party was a native who had worked under American engineers in North China. He hustled the work right along, but, as said above, an American in the lead always brought the best results.

The level lines followed the roads as far as possible. These roads meander in every direction and have a pathway of granite slabs about the dimensions of our ordinary curbstones. These stones lay flat, however, two slabs wide, on an earth embankment.

In carrying the levels across the Pearl River, which is something over a quarter of a mile wide, three bamboo poles were placed in line in the shallows on each side of the stream and at right angles to it. At the dropping of a flag a line was drawn on each pole at the water surface in turn with a knife, taking the outside pair first, the middle pair next, and the inshore pair last. This was done as rapidly as possible. The mean of the three was called the elevation on the far side.

This ten miles of road is all fill. It passes through a country which is irrigated by the tides. The dikes are all high enough to keep out the high tides, and when the farmer wishes to irrigate his rice he simply cuts a hole in the dike or opens a sluice gate. In order to leave head room for the boat traffic in the streams and canals, the bridges

*An article on this railway was published in Engineering News of Jan. 14, p. 43.

†30 West 44th St., New York City.

must be 10 or 15 ft. above high tide. Thus, to save expensive filling the whole length of the line, a grade 3 or 4 ft. above the original profile was established, and at the streams the elevation for the bridges is attained by vertical curves. The number and size of the vertical curves on this work would be a matter of interest in some future report after the operation is well established.

The Chinese method of measuring earthwork is by the fong, as they call it, which is a square 10 (Chinese) ft. wide, 10 ft. long and 1 ft. deep. It is rather more convenient than our cubic yard. The chang or Chinese foot is about a quarter longer than our foot, but varies in the different provinces and among different workmen at the same place. For example, the mason's chang will differ in length from that of the carpenter. The system of weights and measurements of the Imperial Maritime Customs will, however, prevail as standard in time to come.

Masonry is cheap in China, so much so that the late Capt. W. W. Rich proposed that all bridges over shallow waters be built of 30-ft. steel girders and many piers instead of long spans and a small number of piers. If the writer is not mistaken, he did do this on some of the road he built in North China. The dry masonry of the bridges, temples and pagodas about Canton is of a massive nature, and the joints are so closely fitted that often the eye cannot detect the joint. Concrete floors in some of the temples are more than a thousand years old, and are still in good condition. In every hamlet the threshing floors are made of mortar spread on the ground. These floors seem to last for a period of years. The use of piling for foundations is a common native practice. The larger bridges are composed of a series of ovoid or semicircular arches, generally an odd number of arches; the material being a red sandstone. The smaller bridges are a couple or series of piers with stone beams laid across loosely on top from pier to pier, just as we would erect a plank staging. These beams frequently exceed 20 ft. in length by 2 ft. wide and 6 or 8 ins. thick; the material is a hard variegated granite the same as they use for pavements, etc. This granite is similar to that used by the Egyptians, and also very similar in color but of finer texture than that found in Texas, and of which the State Capitol at Austin, Texas, is built.

There are but few foreign educated Chinese engineers. Man for man, however, they are easily superior to Japanese engineers. One has but to look over the records of the Chinese who have studied at Yale University and compare those records with those made by Japanese in the same institution to see the reason for this. The fact that almost the entire clerical force in the foreign banks in Japan is composed of Chinese, as well as the fact that Japanese banks doing business in other Oriental cities employ great numbers of Chinese, proves that in a position of trust the Chinese are a shade more to be depended upon.

As mechanics, the Chinese are showing ability. One has but to walk through the Kowloon shops at Hong Kong to be impressed with this fact. These shops compare favorably in equipment and efficiency with any shops in the world. There are four or five foreign foremen, and all the machinists are Chinese. There you will see a gang running a 20-ton steam hammer, another gang turning a shaft for an ocean steamer on a lathe; here a man running an American turret tool machine; and all of them get no more supervision than an ordinary American machinist would get from his foreman in this country.

It is proposed to operate the Hankow-Canton Railway entirely with Chinese. Of course there will be an American manager, a few engineers, and a master mechanic, but the great bulk of the operatives will be Chinese.

There are no engineering difficulties on this railway. One thing, however, which will increase its cost is the fact that the dead of China are buried wherever a convenient place is found, and a line must be laid out which will strike the smallest number of graves. Naturally in a swampy country the high land which a railway would of course seek is entirely covered with graves. It is heartbreaking to have a line full of curves in a perfectly flat country.

In dealing with the country people while passing over their lands, it was found that they were very appreciative of consideration on the part of the engineers. Frequently the local officials opened the village temples for us to take our lunch in. Whenever any of them came with complaints they were always given the greatest attention. In case of any slight damage to crops, payment was made in cash on the spot. American engineers would do well to always treat the natives of a foreign country where they are at work with a great deal more courtesy than they are compelled to treat their own people in this country. Most of them do this, but a few of them are careless; this carelessness is sometimes very expensive. There was one case in which our line ran within 200 ft. of the front of a small ancestral temple in a poor village. The old headman came out near us several times as we were working past the place, and at last gathered enough courage to say that he thought it would be bad luck if a road was built in front of his family temple. When we set up the fact that a road was already there and pointed out a tiny path, he at length agreed that two roads wouldn't be any more bad luck than one and invited us to take tea with him.

The population of Canton is estimated at two millions. That of Fat San at half a million. The transportation between the two places was formerly only by boat, taking three hours. That this division of the road will pay well goes without saying. As for the main line, well-informed Chinese say that it cannot pay, and will not be able to compete with the old water route. Undoubtedly it will take some years to develop the through traffic to a paying basis after completion. The road must depend almost entirely on its long haul, as the country it passes through will have to be developed. This country is rich in minerals, and will eventually exert a great influence on the world's supply of coal.

The late Captain W. W. Rich was Chief Engineer on the line. His death was no doubt a great loss to the enterprise, as his experience on former railway work in that country was very valuable. His many friends may like to know that one of his last acts was to walk over the line then located from Canton to Fat San—quite an exertion for a man of his age, but he wanted to see for himself that the location was as it should be. It is pleasant to know that he did his last work with that thoroughness which characterized his success on the many miles of railway which he built in America.

The Russo-Japanese war now begun will cause a period of fermentation among the populace throughout China. The Cantonese are the most turbulent element in the empire. It is highly possible that, in the light of former experience, under the circumstances, work, or even further survey on the main line will be wisely abandoned. The Canton-Fat San-Sam Shin branch (about 30 miles in length) is about finished. There were 20,000 coolies at work on it in January rushing it to completion.

A CONCRETE-STEEL PIER AND GIRDER FOOTING FOR RETAINING WALLS.

In constructing some 1,600 ft. of masonry retaining wall near Philadelphia, Pa., the Pennsylvania R. R. engineers have made use of a novel foundation or footing construction in reinforced concrete. The wall proper is of a coursed rubble masonry and will, when completed, carry one side of a series of freight sheds. The foundation construction is the feature of prime interest, and this is shown by Figs. 1 and 2.

Masonry piers 2 ft. square were sunk to firm ground and spaced 14 ft. apart in the clear. On these piers there was built a girder of T-section of reinforced concrete. The web of this girder is 12 × 18 ins., and the flange is 22 ins. wide and 6 ins. thick. The general design of the reinforcement used is shown by Fig. 2, but in the actual construction four instead of two straight tension bars were employed. The concrete was a 1-3-5 trap rock mixture. The girders were designed by Mr. J. O. Ellinger, of New York city.

FIG. 1. VIEW OF CONCRETE-STEEL PIER AND GIRDER FOOTING FOR MASONRY RETAINING WALL.

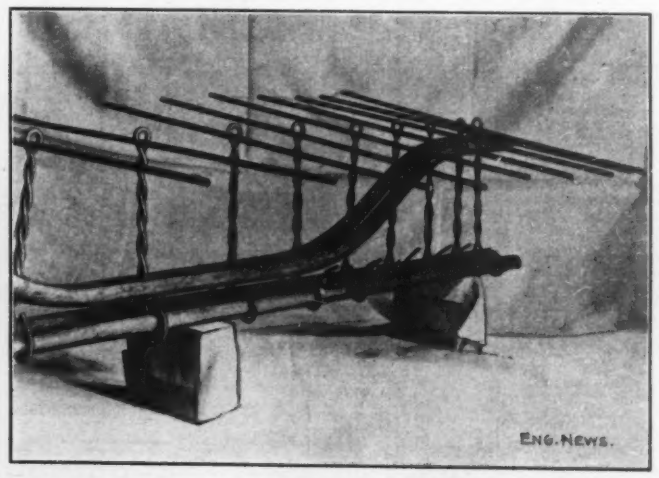


FIG. 2. VIEW SHOWING REINFORCEMENT OF GIRDER FOOTING FOR RETAINING WALL.

AN IRRIGATED SUGAR PLANTATION IN THE SANDWICH ISLANDS.

By C. H. Kluegel, M. Am. Soc. C. E.

The Hawaiian sugar crop for 1903 was 438,000 tons, of which the island of Oahu produced 121,000 tons. Owing to the wide range in the amount of rainfall in different localities, from an annual average of 8 ins. to 175 ins., irrigation is necessary on some plantations, while on others there is an abundance of rainfall for the growth of cane. On the irrigated plantations rainfall and irrigation together amounting to 140 ins. per year, are generally ample for cane growth.

On the islands of Maui and Kauai most of the water for irrigation is supplied by mountain streams whose sources are in regions which have a much greater rainfall than the irrigated fields

On the Island of Oahu, the greater portion of the water supply is derived from bored wells. There are no less than 400 such wells. The water rises from 10 to 30 ft. above sea level. There are numerous springs at this elevation, very few above it. On the lowlands the flow from wells is used for irrigating rice fields, but the greater portion of the water is used for the irrigation of sugar cane.

The Oahu Plantation is a typical irrigated sugar plantation in which nearly all the water used is taken from wells and delivered by pumping. The yield of this plantation in 1903 was 29,250 tons of sugar. The Oahu Sugar Co., Ltd., was incorporated in 1897. It controls about 13,000 acres of cane land, which with the exception of a small area owned, is held under long leases. The land rises from the shores of Pearl Harbor to an elevation of 650 ft. At present the area under cultivation is 7,200 acres, the highest elevation of which is 550 ft. The land is plowed with steam plows to an average depth of 20 ins. Distributing ditches and reservoirs are located for convenient irrigation. The cane is planted in large level furrows, 5 or 6 ft. apart, and not over 3 ft. long.

The favorable season for planting is from July to September. If planted in this season the cane blossoms in the second November thereafter. It is then ripe and ready for harvesting. Following this crop of plant cane two ratoon crops are generally grown before the fields are again plowed and planted. The cane is irrigated every eight or ten days unless there is sufficient rain to make this unnecessary. Each irrigation is equivalent to about 3 ins. of depth over the entire field. Artificial irrigation is continued for about fifteen months for each crop.

Bored wells, 66 in number, furnish the water supply except a small portion which comes from mountain streams. Three of these wells supply the mill. The average depth of the wells is 600 ft. The casing has an inside diameter of 12 ins., and it extends down to the rock. The formation in the lowest 100 ft. or more of the wells is generally a very porous lava rock, which provides a very free flow to and into the wells. The wells at a pumping station are generally spaced 50 ft. apart.

TABLE I.—Analysis and Specific Gravity of Stockett Coal.

	Moisture, %	Volatiles, %	Fixed carbon %	Ash, %	Sulphur, %	Specific gravity.
Top coal	4.35	30.90	54.90	9.85	2.56	1.29
Top bench	2.85	28.95	53.45	14.75	1.64	1.29
Gray coal	3.05	25.10	51.55	20.30	1.33	1.75
Blacksmith coal.	2.65	35.85	51.35	10.15	1.45	1.29
Coking coal	3.01	29.55	52.09	15.35	1.92	1.44

TABLE II.—Specific Gravity of Material Mined at Stockett.

Sulphur balls	4.140	Gray coal	1.751
Slate	2.402	Coking coal	1.440
Bone	1.963	Other coal	1.290

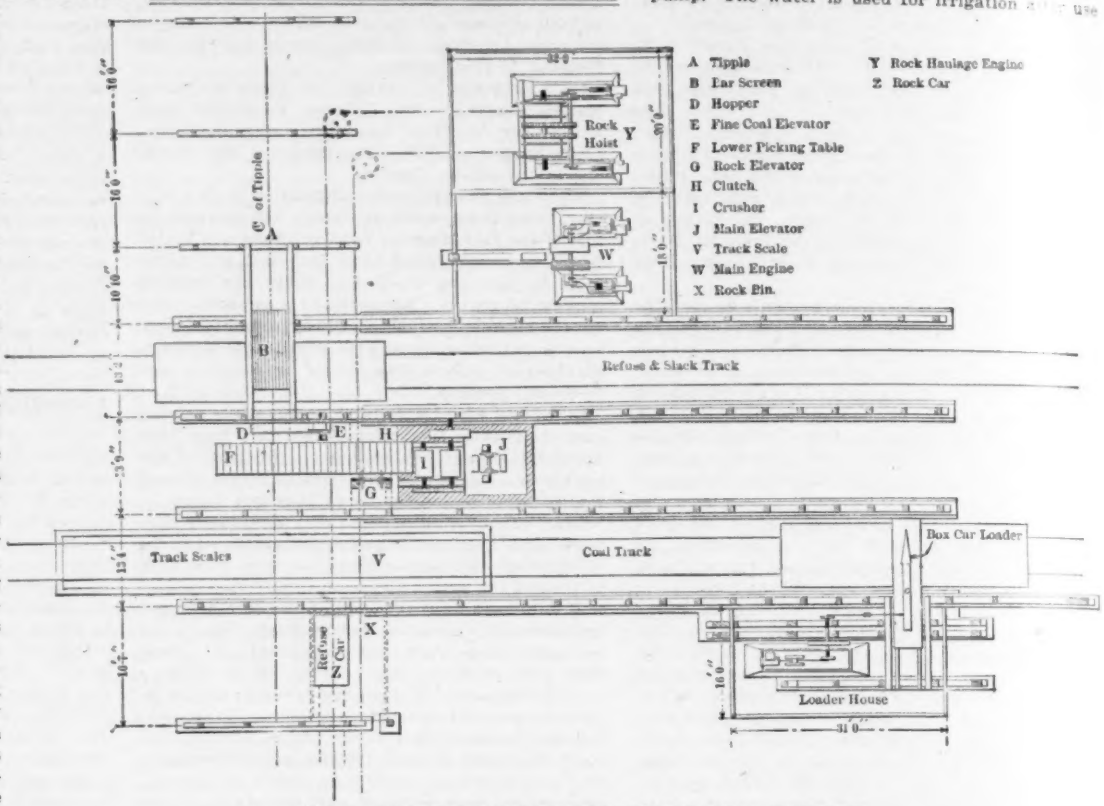


FIG. 1. GROUND PLAN OF BITUMINOUS COAL BREAKER.

The average amount of water drawn from each well is about 1,500,000 gallons daily.

The location of the pumping stations was determined by the topography. Several of the pumps are in pits 30 to 60 ft. deep. One pump is in a chamber at the bottom of a shaft 280 ft. deep. The present pumping plant for irrigation consists of six Riedler pumps with capacity per 24 hours as follows: two 10,000,000-gallon pumps, two 8,000,000 gallon pumps, one 12,000,000 gallon pump, one 9,000,000 gallon pump. The highest lift is 530 ft. Several smaller pumps are used in case of emergency. Six wells flow into the irrigation ditches without pumping. The cane mill is supplied by a 5,000,000 gallon Worthington pump. The water is used for irrigation after use in the mill. The Riedler pump was used on the Oahu plantation, and had been introduced for irrigation in Hawaii on the recommendation of the writer, who was then engineer for the Oahu Sugar Co.

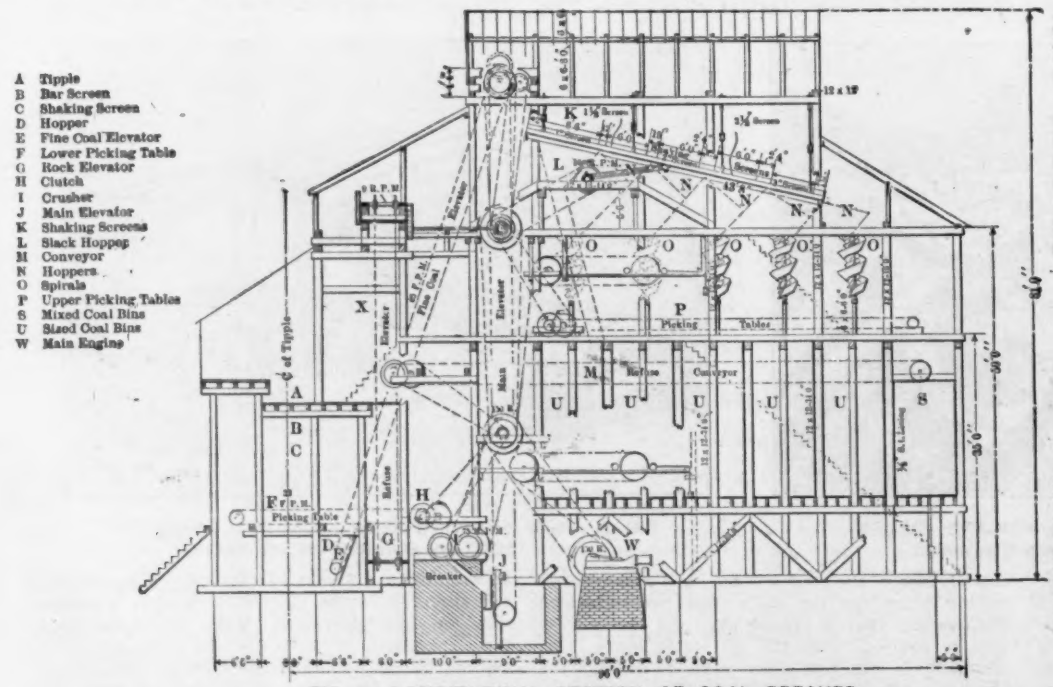


FIG. 2. LONGITUDINAL SECTION OF COAL BREAKER.

Recently oil fuel was substituted for Australian coal at the pumping stations. The saving at local prices has been 35%. At the mill no other fuel is required than bagasse or cane trash.

For the delivery of water into the irrigation flumes and ditches riveted pipe is used, there being 11,000 ft. of 30-in. diameter, and 28,000 ft. of 24-in. diameter.

The length of permanent railway track is 38 miles and portable track 10 miles. All the cane is brought to the mill on cars hauled by steam locomotives. The mill has a capacity of 225 tons of sugar in 24 hours, produced from about 1,700 tons of cane. Mr. August Ahrens, who has had 25 years experience in the sugar industry, is the manager of this estate.

A BITUMINOUS COAL BREAKER.*

By Lewis Stockett,† M. Am. Inst. Min. E.

During the year 1903 a building and machinery corresponding to an anthracite coal breaker was erected at the town of Stockett, Cascade county, Mont., for the purpose of breaking up and cleaning bituminous coal.

The coal is mined from a vein of the Kootenai group of Lower Cretaceous measures having the following section:

	Ft.	Ins.	Ft.	Ins.
Sandstone ledge	..	..	..	..
Top coal	1	2	..	..
Slate	..	..	0	5
Top bench	1	6	..	..
Bone	..	..	0	7
Gray coal	1	3	..	..
Blacksmith coal	2	5	..	..
Bone	..	..	0	6
Coking coal	1	5	..	..
Metamorphosed fire-clay	..	..	..	..
Total, coal	7	9	..	..
" sterile material	..	..	1	6
Grand total			9	3

The vein is nearly horizontal in position, and each bench differs in quality as shown in Table I.

*A paper read at the Atlantic City meeting of the American Institute of Mining Engineers, February, 1904.

†Mgr., Coal Properties, Great Northern Ry., Stockett, Mont.

There are no partings whatever between the different benches of coal, slate and bone, the vein being very hard and a solid mass from top to bottom, which with a liberal number of pyrite nodules, called sulphur balls, scattered promiscuously throughout the vein, make the coal a difficult one to clean. Previous to the building of the breaker, the cleaning was done with indifferent results by the miner at the face, and the nut-coal was washed in a tig. Scarcity of water, however, prevented the erection of a plant to wash the whole product, and at times necessitated the shutting down of the nut-coal washer.

The difficulties to be overcome in separating the different

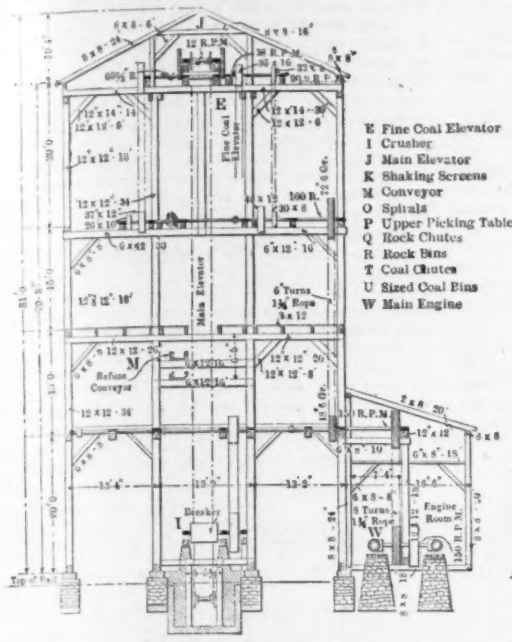


Fig. 3. Transverse Section of Coal Breaker Showing Machinery.

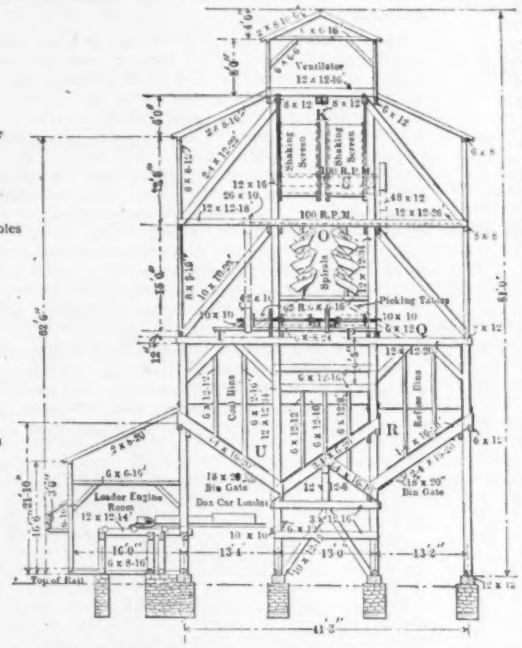


Fig. 4. Transverse Section of Coal Breaker Showing Bin.

material of the vein will be appreciated by a study of their specific gravities, shown in Table II.

After a series of experiments, a scheme of treatment supplementary to the cleaning by the miner was determined upon and carried out, one of the requirements being so to connect the new work to the old tipple that the change could be made from one to the other without delay in the shipment of coal. This arrangement was successfully accomplished and accounts for some things about the building that may be open to criticism—things which would be arranged differently in an entirely new plant. Ground was broken for the foundations of the building, March 26, 1903, the timber work was commenced April 16, the machinery started Aug. 10, and has since been in continuous operation every week-day with gratifying results.

The following illustrations have been prepared from the working drawings to show the general arrangement of the plant and the manner in which the machinery has been installed: Fig. 1. Ground plan; Fig. 2. Longitudinal section showing especially the machinery; Fig. 3. Transverse section showing the machinery; Fig. 4. Transverse section showing the bins; Fig. 5. Plan at the screens; and Fig. 6. Section of the tipple. The letters in the text of this paper, referring to the legends, are common to all of the illustrations.

The coal, carried from the mine in pit cars of a capacity averaging about 1.5 tons to the car, is weighed on an automatic scale and thence dumped by the cross-over tipple A, over the bar-screen B, 12 ft. long, 6 ft. wide and having a pitch of 6 ins. to the foot with spaces between the bars 2 ins. wide, which screens out that portion already small enough (about 30% of the total), and, falling on the shaking screen C, having 1-in. round perforations, 6-in. throw and 100 strokes per min., removes the slack from the coal. The slack is loaded directly in the railroad car or taken to the boiler room by means of a wire rope conveyor. The portion of the coal that goes over the shaking-screen C slides into a hopper D, from which it feeds into an elevator E, consisting of a rubber belt 16 ins. wide, having 8 × 14-in. buckets placed every 16 ins. and operated with a speed of 225 buckets per min., which elevates the material to the top of the building.

The coal that passes over the screen B falls upon a traveling belt F, 4 ft. 6 ins. wide and 26 ft. long, having a speed of 33 ft. per min.; and from this belt any large pieces of slate or other impurities, such as machine picks, car-couplings, sprags, etc., are removed by men stationed on either side and thrown into a rock-elevator G. This traveling band is operated by a clutch gear H, which in case of a very large quantity of impurities appearing is thrown out, the belt stopped and all the impurities removed before the coal drops into the rollers I, which reduces the coal to a size not exceeding a 4-in. cube. It was found necessary to reduce to a 4-in. size in order to prevent the concealment of a sulphur ball in a lump of coal. The rollers are of the removable-tooth style, 36 ins. in diameter, 48 ins. wide and revolve at 75 revs. per min.

From the rollers the coal is elevated by a continuous elevator J, having buckets 12 × 30 ins. and operated at a speed of 65 buckets per min. Each bucket has a capacity of 110 lbs. of coal when level-full, which is equivalent to 200 tons per hour; the capacity of the fine coal elevator E is 90 tons per hour, giving a combined elevating capacity of 290 tons per hour, or 2,900 tons per day of 10 hrs., an amount which added to the slack screened out at C gives a total capacity of 3,200 tons per day.

The coal elevated by the elevators E and J, is evenly divided over the shaking screens K, 5 ft. wide and 46 ft. long, having a 3-in. pitch to the foot, a 6-in. throw and 100 strokes per min. The plates of the screens have respectively 1, 1.5, 2, 2.5, and 3-in. round perforations, and separate the coal into slack, pea, nut, stove, egg and broken sizes.

The slack resulting from the breakage of the coal is found to be clean, and, not needing any further preparation, it descends through the hopper L to the top strand of the conveyor M (having 10 × 20-in. flights spaced every 3 ft.), and taken directly to the mixed-coal bin S. The other sizes are fed by means of the hoppers N into spiral separators O, which separate the greater part of the impurities from the coal. These impurities pass either to the lower strand of the conveyor M and are conveyed to the rock elevator G, or from one set of spirals to the bins R, by means of chutes Q, which give an opportunity to repick the refuse by hand and save any coal that may be in it. The refuse is finally loaded into railroad-cars and used by the railroad for widening banks, etc.

From the spirals O the coal drops onto two picking bands P, 4 ft. wide, 50 ft. long and having a speed of 40 ft. per min., which convey it to the mixed coal bin S and gives an opportunity to pick out by hand any impurities not removed in the spirals; from one set of spirals, inclined chutes T pass the coal into bins U for loading straight sizes, any remaining impurities being removed by hand while the material is on these chutes.

The rock elevator G, having continuous buckets 12 × 30 ins. and speed 50 buckets per min., elevates the impurities into a bin X, from which it is loaded into a 6-ton car and hoisted by a pair of geared tail-rope engines, with 10 × 18-in. cylinders, to the top of the adjoining hill and automatically dumped.

The machinery of the entire plant is driven by a double engine W, with cylinders 13 × 18 ins., running 150 revs. per min.; the connection to the first and second line shafts being made by rope drives, and all other connections, by rubber belts.

From the bins S and U the coal is loaded into railroad cars, a box-car loader being placed opposite the chute S to load box cars. The cars are weighed on the scale V, and it may be of interest to know that when loading the mixed coal into box cars, the entire product of the breaker passes through an opening 12 × 14 ins. in area.

The building is heated by steam-coils supplied with live steam, and is lit by incandescent electric lights. It has two stand-pipes with hose connections and hose for fire protection.

On account of the slight difference in the specific gravity of the gray coal and the bone, the spirals are adjusted so as to retain only the slate and flat sulphur balls, leaving the bone to be removed by hand. The round sulphur balls which on account of their shape are the first to leave the spirals and go with the coal, also have to be removed by hand.

The results obtained are given below, showing the percentages of refuse in the various sizes. In pea coal, 4: in nut coal, 3; in stove coal, 3; in egg coal, 2; in broken coal, 1; and in mixed coal, 2.5%. Of 2,000 tons of the mine product, which is daily dumped into the breaker, 200 tons of the various impurities are removed, and these impurities do not contain on an average over 1% of coal.

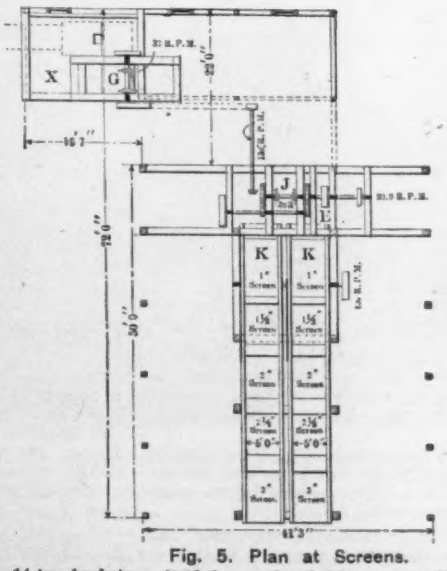


Fig. 5. Plan at Screens.

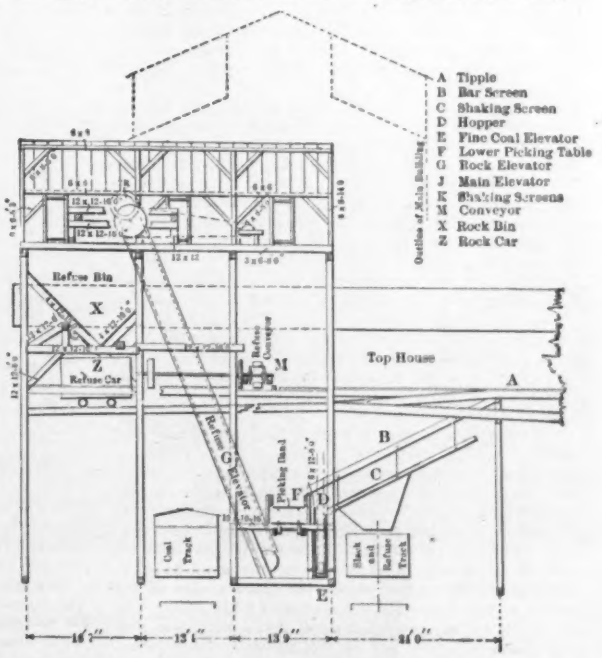


Fig. 6. Section of Tipple.

The mixed coal is used by the railroads as a locomotive fuel, and proves an excellent article; the various sizes are used in the commercial trade, the slack and pea sizes making the very best of boiler fuel.

The cost of the breaker, in the section where the highest wages are paid in the United States, and where freight is a very large item, was $42,517.90, divided as follows:

General expenses...	$472.45	Hardware.....	$805.91
Foundations.....	2,445.46	Labor.....	10,700 82
Lumber.....	3,607.31	Freight.....	8,844.13
Machinery.....	12,764.89		
Separators.....	2,753.18	Total.....	$42,517.90
Scale.....	123.75		

The above figures include 300,000 ft. of lumber and 400 yds. of masonry as well as duplicate pieces for all of the parts of the machinery that are liable to break or wear out.

The cost of operation of this plant over and above the force previously used on the old tipple is as follows:

Coal inspector on lower picking band.	$3.00	1,500 tons (1,800 — 300 slack) pr ton	$0.03
3 men on lower picking band	7.50	To which add interest on investment, taxes, insurance, wear and tear, supplies used and repairs, which as near as can be estimated is	.03
1 man looking after screens	2.56		
1 man looking after spirals	3.00		
15 boys picking slate, etc.	15.00		
1 breaker boss	3.00		
1 engineer,also hoists the rock	4.00	Total, additional cost pr ton	$0.06
1 machinist, oils and keeps machinery in order	3.50		
1 man loading rock.	2.50		
	$44.00		

The largest item of cost, however, comes from the decreased production from what was formerly shipped, by reason of the removal of the impurities; the total cost being now divided by 1,500 tons of lump-coal as compared with 1,700 tons formerly; this is met by the increase price received for the coal, and which at the increased price is a cheaper fuel to the consumer than the former product at the lower figure.

The success of this plant will make available large fields of coal in Montana, which on account of the impurities present were hitherto regarded as unworkable. However, it is only with coals hard enough to keep their shape, and where a marked difference exists both in the specific gravity and the shape of the coal and the impurities, that the spirals will work successfully.

THE ELECTRIC STEEL FURNACE AT GYSINGE, SWEDEN.*

By F. A. Kjellin.†

The problem of smelting steel by electricity attracted years ago the attention of inventors, and as early as 1879 C. W. Siemens constructed his first furnace for the smelting of metals, especially steel. His furnace was of the arc type, in which the voltaic arc was formed between a carbon electrode and the metallic content of a crucible, the length of the arc being regulated by an electro magnetic device.

This electric furnace, as well as others of similar construction, has the inconvenience that the source of the heat—the voltaic arc—possesses a temperature of 3,700° C., which is much more than that required by steel smelting. The result of the use of this intense heat is that the steel is overheated in the vicinity of the arc, while in other parts of the furnace it has not yet reached the temperature suitable for teeming. Another inconvenience is that the steel very easily takes up impurities from the electrodes consumed.

The cost of the electrodes also is an item that sensibly increases the cost of production, and the carbon monoxide resulting from the oxidation of the electrodes exerts a bad influence, as it prevents the steel from giving off the carbon monoxide dissolved in it. A more uniform heating of the steel can be obtained by passing electric currents of great intensity through the steel, and using the heat evolved by the resistance of the steel for the smelting. But as the resistance of metals, even when molten, is comparatively low, the currents used must be so great that copper cables get a section at least as great as that of the steel in the furnace.

Mr. de Leval, the well-known Swedish inventor, has tried to diminish this inconvenience by using molten slag instead of steel as resistance in his furnace; but the results cannot have been satisfactory, as the patent has been allowed to expire.

The greatest difficulty in electric furnaces of this kind comes from the electrodes, for the reason that carbon electrodes have high resistance, cause great losses of tension and power, and are soon consumed at the contact with molten steel. Water-cooled iron electrodes could possibly be used, but then the magnetic properties of the iron create new difficulties. In order to get sufficient intensity of current, alternating currents must be used, and then the magnetism causes the concentration of the current at the surface of the electrodes (skin effect), and the result is great current density in the electrodes with great losses of power, and by the influence of self-induction a diminished capacity of the electric generator to convert mechanical energy into electric energy.

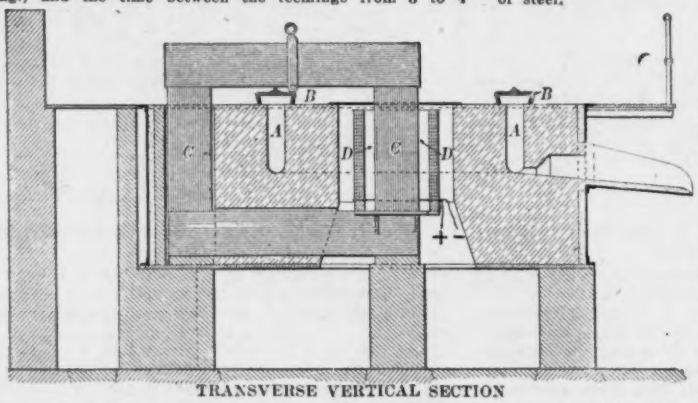
In order to eliminate these difficulties I proposed to Mr. Benedicks, general manager of the Gysinge works, in May, 1899, to build an electric furnace at Gysinge, without electrodes. My project was accepted, and I went to Gysinge to carry it out.

The illustration, Fig. 1, shows the principle of the furnace. An annular groove A A forms the furnace room, the sides and bottoms of which consist of refractory bricks. The covers B B close the furnace. In the center of the circle formed by the furnace room is a quadrangular core or cone C, formed of thin insulated copper wire, which continues outside the furnace, and forms with the furnace room the two links of a chain. The coil D D is connected with the poles of an alternating current generator.

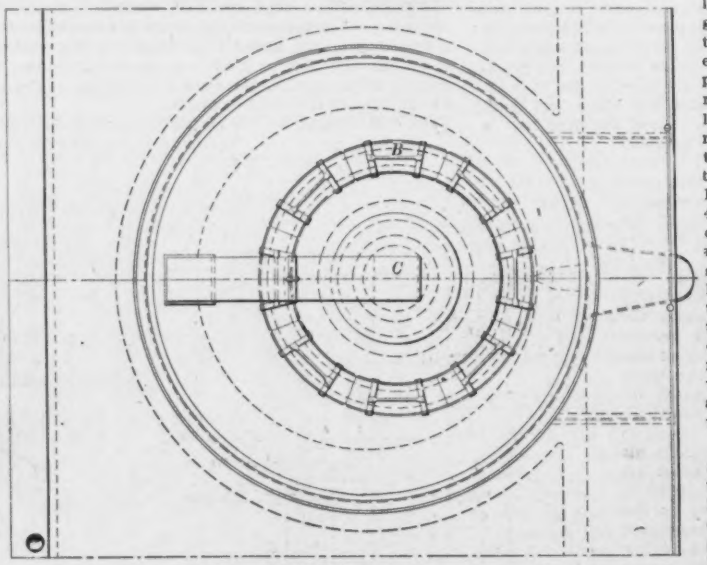
When passing through the coil the current excites a varying magnetic flux in the core or cone, and the intensity of current in the steel is then almost the same as the primary current multiplied by the turns of wire in the primary coil. The tension of the current is naturally reduced in almost the same ratio as the intensity is increased. In this way it is possible to use an alternating current generator of high tension, and yet—without using transformers with copper cables of large sections and powers, and costly electrodes—obtain a current of low voltage and great intensity in the furnace.

In February, 1900, the first furnace at Gysinge was ready for use, and by March 18 the first steel ingot was cast, which from the beginning was of an excellent quality. The problem was then solved technically, but not economically, for, with an electric generator of 78 KW., only 270 kg. of steel were produced in 24 hours.

The next furnace built was ready in November, 1900, and produced with 58 KW. from 600 to 700 kg. of steel ingots in 24 hours. The charges were composed of 100 kg., and the time between the teemings from 3 to 4 hours. The output was not fully satisfactory, because the cooling surface of the walls was too great compared with the contents of the furnace, and the cost of repairs was also rather high.



TRANSVERSE VERTICAL SECTION



PLAN

PLAN AND VERTICAL SECTION OF THE KJELLIN ELECTRIC STEEL FURNACE.

On August 11, 1901, the sulphite pulp mill of Gysinge was completely destroyed by fire, and it was then resolved not to rebuild it, but to use for steel smelting the water power formerly absorbed by the pulp mill.

The new plant was ready to start in May, 1902, and has since that time worked satisfactorily. It consists of a furnace containing 1,800 kg. of steel, from which from 1,000 to 1,100 kg. are taken out by each teeming, and the rest left to keep the current passing. The furnace produces with 105 KW., or 225 E. HP., 4,100 kg. of steel ingots in 24 hours when charged with cold materials. The electric generator gives alternating single phase current of 3,000 volts, which is directly transformed, by means of the primary coil and iron core of the furnace, into a current of about 30,000 amperes in the steel that forms the secondary circuit.

The smelting process as carried on at Gysinge produces only first-class steel, from the excellent Dannemora pig iron and weld iron, as follows:

After teeming, about 800 kg. of metal is left in the furnace to keep the current passing, and to this is added the proper quantities of pig iron, bar ends and steel scrap as experience has proved will give the percentage of carbon desired in the resultant steel. In teeming there is always less carbon in the steel than that contained in the materials charged, for the reason that the pig iron is rusty and the steel also takes up a little silicon by reduction of the silicic acid of the lining. When the charge is molten and over-heated to a suitable degree, the teeming is done in the same way as in the open-hearth furnace, by making a hole in the wall. The upper part of the furnace, as shown in Fig. 1, is on the same level as the working floor, and the charging is done simply by taking off the covers and putting in the materials. As the heat is produced in the steel itself, the slag is not so hot as in other steel furnaces, and consequently the workmen do not suffer much from the heat. The steel produced is, as mentioned above, of an excellent quality, uncommonly dense, unusually homogeneous and tough, easy to work cold when annealed, and less disposed to crack and warp in hardening than other kinds of steel. I think that the cause of these excellent qualities, apart from the good raw material used, must be due to the fact that the product contains less dissolved gaseous matter than other kinds of steel.

As every one knows, even small quantities of gases, especially hydrogen, injure the quality of steel, and the principal cause of the high quality obtained by smelting in crucibles is, in my opinion, that the steel is not in contact with the fuel gases, though it may absorb a little through the porous walls of the crucible. In the electric furnace described above, the steel has no opportunity to take up such gases or other impurities, and the quality is even better than that of the crucible steel with the same analysis.

To make special steels with nickel, tungsten or chromium, offers no difficulties, and the alloys themselves are quite homogeneous. The cost of production depends principally on the efficiency of the furnace and the price of the power. In the furnace now in use at Gysinge the losses have been proved experimentally to be 87.5 KW., so that the effective power absorbed by the steel is 165 — 87.5 = 77.5 KW.; and, as those produce 4,100 kg. of steel in 24 hours, one effective kilowatt produces about 53 kg. of steel ingots in the same time. Every additional kilowatt in the furnace, when the size is not altered, increases the output by 53 kg., and it is calculated that within a few months when a stronger water wheel is obtained, to produce about 6,000 kg. of steel ingots with 200 kilowatts.

As the absolute cost of labor and repair will be the same, those costs for one ton of steel ingots will be about two-thirds of the present cost, and the price of power per ton also will be sensibly diminished. At Gysinge the cost of repair (renewing the lining of the furnace when it is worn out) was $60.

From experience with this furnace it is calculated that a furnace of 736 KW., or 1,000 E. HP., will produce 30,000 kg. of steel ingots in 24 hours, when charged with cold materials. With hot materials the output is much greater. For instance, if 250 kg. of molten pig iron are charged for each ton of steel ingots produced, the output is increased from 30,000 to 36,000 kg. in 24 hours, with 1,000 E. HP.

In my opinion, the costs of labor and repairs for a furnace of this type will be less than those of an open-hearth furnace of the same size; so that, where power is cheap, there is a possibility of producing a steel competing with the expensive crucible steel at a smelting cost not exceeding that made in the open-hearth furnace.

*A paper read at the New York meeting of the American Institute of Mining Engineers, October, 1903.
†Gysinge, Sweden.